

EXPLORING TENSIONS, IDENTITIES, AND EQUITABLE SCIENCE ASSESSMENT
PRACTICES IN UNDERGRADUATE AGROECOLOGY EDUCATION

A Dissertation
Presented to
The Faculty of the Graduate School
At the University of Missouri

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

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MAY 2015

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EXPLORING TENSIONS, IDENTITIES, AND EQUITABLE SCIENCE
ASSESSMENT PRACTICES IN UNDERGRADUATE AGROECOLOGY
EDUCATION

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DEDICATION

This dissertation is dedicated to my wife, Erin, and our daughter Josephine. Erin, you inspire me everyday through your hard work and compassion. It is scary to imagine where I would be, or *who* I would be, if I hadn't met you.

Josephine, you have given me a heightened perception of my privileged role and responsibility on this planet and expanded my ability to love.

Erin and Josephine, this is for you.

ACKNOWLEDGEMENTS

This study is a product of my participation in several different communities of practice and would not have been possible without the significant intellectual contributions and unending support from my colleagues, friends, and family. I thank my committee for providing flexibility and open-minded acceptance of the multiple identities I assume in my research and teaching. Marcelle Siegel, you have been such a supportive advisor and chair for my dissertation committee. I am greatly indebted to you for your patience to endure my underdeveloped musings as I tried to figure out exactly what it is I was trying to say. You have helped me develop my voice as a researcher and writer and for that I am perpetually grateful.

Mary Hendrickson, you gave me the chance to participate in re-envisioning your Advanced Practices of Sustainable Agriculture course. Thank you for your willingness to “jump-in head first” while we enacted alternative, student-centered assessments and curriculum. I hope to eventually attain your remarkable ability to coordinate and build strong relationships with and between faculty members, students and local farmers to help make progress towards sustainability in our food system. Above all, you have helped me understand the value of pragmatism, a skill I am still practicing. Thank you.

Anna Waldron, you have been such an inspiring mentor, leader, and interdisciplinary communicator. I hope to be able to seek your candid advice throughout my career. Troy Sadler, thank you for having an open door and for challenging me with questions that helped position my research in the world of science education.

Peggy Placier, your course on the History of US Education Policy altered the way I viewed the problems and promises of education. You introduced me to Joel Spring,

Paulo Freire, Myles Horton and others who are constantly in my head framing the questions I ask and decisions that I make. For all of these contributions, thank you.

Parker Stuart, you gave me uncountable rides home from our evening classes and conferences, when I was too stubborn to own a car, and helped me learn how to “talk shop” while we considered and struggled with our future roles as science education researchers.

There are countless other colleagues and friends who have contributed to the ideas contained within this dissertation: Jordan Dawdy, Lebo Moore, Adam Saunders, Dan Soetaert, Bill McKelvey, Mike Burden, Sandy Rikoon, Suleyman Cite, Gina Applebee, and the MU Science Education graduate students. Thank you all for being an audience and an inspiration.

Thanks to all of my collaborating instructors and students, who shared their stories, experiences, concerns, and visions for the future. Specifically, Emmie Harcourt, Matt Miller, Molly Pershing and Jessica Hill have provided valuable insight by reading numerous drafts of this dissertation in different phases.

Finally, without the unending support of all of my family members, it simply would not have been possible to complete this dissertation. Mom, Tami Corvello, thank you for teaching me how to love unconditionally. Dad, Daniel Murakami, thank you for teaching me to pursue my passions. Ken and Dinah Pearson, thank you for the uncountable home cooked meals and for welcoming me to your family. Erin Pearson, thank you for having the unwavering faith and expectation that I would finish. Josephine Pearson Murakami, thank you for giving me a new sense of purpose as a parent.

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ABSTRACT

National reform documents suggest that changing pedagogical and assessment practices in college science courses are necessary but challenging steps to help support the formation of science identities. This dissertation is a collection of three separate research manuscripts that examined the challenges and affordances of designing and enacting curriculum and assessment practices in an upper-level agroecology course titled, *Advanced Practices of Sustainable Agriculture*. All three studies integrate theoretical lenses of situated learning, communities of practice, and identity and agency in cultural worlds to support and describe the process of science identity formation. Five instructors and thirteen students participated in the research process. During the fifteen-week semester in the Fall of 2013, pre/post narrative interviews, weekly instructor planning sessions, weekly classes, student assignments, and course artifacts were collected. Interviews were transcribed and remaining data were then analyzed using NVivo10 software and a variety of qualitative methods. The first research manuscript employs case study methodology to explore the sociocultural tensions within the classroom community of practice. Two ethnographic vignettes were used to describe the nature of four interconnected sociocultural tensions: (1) individual tensions, (2) community tensions, (3) local/global tensions, and (4) local tensions. Attending to these tensions that are inherent in student-centered, democratic learning is central to the *wicked problem* of agroecology education. The second manuscript aims to expand the purposes of Science, Technology, Engineering, and Math (STEM) education reform to accommodate disciplines like agroecology that is framed as a Feminist – STEM (F-STEM) discipline. Previous research has focused on the science identity gap that exists for women and other non-dominant groups. Despite academic gains in science courses, women and

underrepresented learners might still feel as if science is not *for* them. Using the voices of three women in the course, the study uncovered aspects of Equitable Science Assessment Practices (ESAP) that support the formation of F–STEM Identities. Inspired by the stories and experiences of the three participants, four features of ESAP were characterized using iterative qualitative analysis and poetic representation: (1) allowing flexibility, (2) sharing authority, (3) laminating voices, and (4) scaffolding social justice. These interdependent features of ESAP that focus on identity formation can provide course design principles and present new opportunities to merge critical feminist studies of science education and equitable assessment. The third manuscript integrated the *mapping* and *tracing* of *rhizomes* with the practice of *reflexivity* in qualitative research to describe a process of *becoming Bermuda Grass*, a rhizome encountered and mimicked by the researcher. The study was initiated when a student participant expressed an identity of non-participation in the course. The article provides a narrative account of applying aspects of rhizome theory and reflexivity to gain new meaning and insight to support learners in an agroecology course. These three manuscripts focus on different grain sizes and help make connections between local contexts and global issues of environmental and social justice. This research contributes a new dimension to a framework for the political ecology of education focused on supporting learner identity transformation through classroom assessment practices.

CHAPTER ONE: INTRODUCTION

“I Feel Like I’m Flying”

Near the end of the last Friday morning group planning meeting before the course started, without any prompts from the multidisciplinary team of instructors, Peter cleared his throat and added, “um, I read something the other day that said the first five minutes of class is the most important.” As an Emeritus Professor of Dairy Science and one of the founders of the sustainable agriculture program at the Large Mid-Western Land Grant University (LMW LGU), his comments tended to hold a fair bit of weight. “So, I think we better have something good planned,” he continued, with a deliberate cadence while folding the bill of a weathered hat with *John Deere* stitched across the back. With some acknowledgement of Peter’s contribution, the agenda was finalized: (1) Introductions, (2) Review Syllabus, (3) Discuss Course Philosophy, (4) Pressing Issues in Agriculture, (5) Recruitment for IRB, (6) Bindweed Case Discussion, (7) Agroecosystems.

Despite Peter’s insights, we opted for the more conventional class opening but hoped that our syllabus, course philosophy and the diverse group of learners (instructors and students) would be compelling enough to enhance student engagement and establish a strong first impression. My recommendations as an outsider were surprisingly prevalent in the plans for the entire course and this first day of class. Despite some initial hesitancy that the *Bindweed Case* would not be relevant for students because it was based on my experience in Urban Agriculture, at the time the decision case I wrote was the most developed, so we went with it. Helen took a deep breath in before concluding, “all right folks, *I feel like I’m flying* but I guess we’re ready,” and quickly transitioned into deep

laughter that captured her anxiety in an attempt to ease any tensions that remained in the group.

Dissertation and Chapter 1 Overview:

This dissertation is about my experiences *flying* with a transdisciplinary group of professors as we designed, implemented, and researched an upper level course in sustainable agriculture. This idea of *flying* reflects emotions of uncertainty and disorientation that all of the participants in this study held (myself included) in our *community of practice* (Lave & Wenger, 1991; Wenger, 1998; Wenger, McDermott, & Snyder, 2002) as we sought to build and participate in a learning environment to help address some of the world's most pressing environmental and social justice issues through local actions in sustainable agriculture education.

Rationale for the Study:

In this first Chapter, I briefly describe the rationale of this study and position this research within empirical work in the fields of political ecology, science education, and sustainable agriculture education before briefly discussing the history of Land Grant Universities (LGUs). Next, I identify three distinct but interconnected lines of inquiry that form the basis for the stand-alone manuscripts that will be submitted to the following peer-reviewed academic journals: (Chapter 2) *Agriculture and Human Values*, (Chapter 3) *Journal of Research in Science Teaching*, and (Chapter 4) *Qualitative Research*. I conclude by providing a brief discussion on identities and reposition this notion of flying as the *improvising* (Holland, Lachicotte, Skinner, & Cain, 1998) that occurs as all learners navigate complex and rhizomatic (Deleuze & Guattari, 1987) sociocultural worlds that are always changing. This discussion is later expanded upon in my concluding chapter to explain the contributions of this dissertation to research on (1)

sustainable agriculture course design, (2) equitable science assessment practices, (3) and post-structural research methodologies.

Political Ecology and the Land Grant University

Political ecology is a multi-disciplinary field of inquiry that explores the role of history, culture, politics and economics in the construction and attempted remediation of environmental issues (Robbins, 2004). Political ecologists integrate social theory and ecology to understand the nature of complex local and global environmental problems and design ways to move towards more equitable and socially just management of human and other natural resources in coordination with diverse stakeholders (Baer & Singer, 2009; Byers, Cunliffe, & Hudak, 2001; Nygren, 2004; Ogden, 2011). Recently, Meek (2014) has applied a political ecology framework to the field of education research to understand the interplay between politics, land usage, and sustainability education. However, political ecologists have yet to examine the role of the public Land Grant Universities (LGUs) as a site for making changes necessary to meet the diverse needs of citizens in the direction of sustainability. This dissertation uses political ecology as a tool to explore learning experiences in a LGU and help clarify the role that these institutions can play in ecological and social change. What follows is a brief history of LGUs and the philosophical tensions that connect to contemporary policies and issues in the fields of science education and sustainable agriculture that provide context for this dissertation.

Land Grant Universities, Education History and Philosophy

Through a series of federal acts, LGUs have become some of the most powerful institutions for creating and disseminating knowledge about ecosystem management through agricultural practices (Campbell, 1995). Beginning in 1862 with the passage of

the Morrill Act that established institutions of higher education in each of the United States and later with the Hatch Act of 1887 and the Smith-Lever Act of 1914 that allocated funding for research and extension services, these institutions have become a center for scientific and technological advancement that have led to widespread changes in how land resources are managed in the United States and abroad. The three-pillar mission of teaching, research, and extension was initially conceived of as a way to provide technical training and critical reasoning skills to working class citizens, during a time when higher education was reserved for only the elite. The research branch works in coordination with industry to develop new technologies that are meant to increase the productivity and profitability of agriculture. Some have criticized this connection between industries and institutions of higher education because of the tendency to serve business interests over the common good (Hightower, 1972). The teaching and extension branches help translate this science and technology into practices that can be disseminated throughout a region. Visions of this model of public higher education began with the fundamental beliefs of founding fathers like Washington and Jefferson, and education reformers like Horace Mann and many others, that all citizens should have access to higher education for the maintenance of democracies and the promotion of industries (Campbell, 1995).

In 1890, over 11 million acres of public lands had been allocated to states to help fund the establishment of LGUs with their associated research stations and extension services. While many states had already founded these Universities that later achieved Land Grant status, these institutions expanded greatly under state control using the interest accrued off the sale of these once federally owned lands (Thelin, 2011). These

state run institutions were free to interpret the original language of the Morrill Act that called for the creation of these institutions of higher education to support both “liberal education” and the “mechanical arts,” such as agriculture. However, these two different views of education, liberal arts and utilitarian, have consistently been in contention. For Thomas Jefferson, the value of higher education and public education in general was that a liberal education in the arts and humanities was critical to ensure citizens would have the fundamental capacities to participate in and consistently improve our democracy (Fraser, 2010). While Jefferson’s definition of a citizen excluded all but white males, the essence of his message that was manifested in his two pieces of education legislature (both of which failed) provided a purpose for investment in public education that others like Benjamin Rush, Horace Mann, John Dewey, W.E.B Dubois and countless other liberal and progressive educational leaders worked towards. However, Justin Morrill and the passage of the series of land grant acts are typically viewed as a shift towards more utilitarian views of education that helped justify public education as a common good because it stimulated the economic machines of a newly industrialized nation (Thelin, 2011). While the LGUs were supposed to provide a foundation in humanities that would serve the maintenance of our democracy and technical training in the mechanical arts, many critics argue that they have favored the latter to their demise. For example, Wendell Berry (1977), a prominent figure in the sustainable agriculture movement, problematized the role that the LGUs have historically played in the degradation of rural communities and agrarian livelihoods in his book, *The Unsettling of America*. Central to his argument is the divergence of these Jeffersonian and utilitarian perspectives in LGUs. This deficit view of the LGUs paints them with broad strokes as static institutions operated by self-

serving professors that operate separately from regional contexts and are resistant to social change. While some of these criticisms might be justified, this dissertation explores LGUs as a necessary and optimal site for progressive education and social change.

Land Grant Universities and Sustainability

Cortese (2003) suggests that institutions of higher education are especially well positioned for supporting the type of knowledge advancements and shifting ideological perspectives necessary to meet the needs of global citizens. I argue that LGUs, with robust resources and a historical mission of serving the interests of common citizens, are especially suited, and have the greatest capacity to envision and enact, education and research programs to make social progress in the direction of sustainability. However, in the present political and economic context, there is still this tension between utilitarian and liberal views of education and the broader philosophical and political question, what is the purpose of public education? In this next section, I briefly summarize this problem of a leaky Science, Technology, Engineering, and Math (STEM) pipeline, describe how it can be viewed as a contemporary version of utilitarian educational philosophies, and highlight important challenges and opportunities that further situate and justify my dissertation study.

STEM Careers and The Humanities

In 2010, the National Science Foundation released, *Preparing the Next Generation of STEM Innovators*, a report that provided groundwork for policy interventions to help the nation recruit and retain talent (NSF, 2010). This report situated the US in a new wave of post-Sputnik reforms to US education policy and practice. This investment is justified by evoking Becker's (1993) notion of *Human Capital*, the

empirically and historically demonstrated return on investment that comes from allocating resources to educate and train a new generation of scientists. This excerpt captures the essence of the arguments embedded in the NSF (2010) report:

A little more than a decade later, mobilized by the Soviet's successful launch of Sputnik, the United States embarked on a collective, coordinated, and sustained effort to recruit and educate the 'best and brightest' who subsequently would form a new generation of leaders and innovators in science and engineering. This effort resulted in unprecedented scientific and technological progress, leading to the creation of new enterprises, new jobs, and the betterment of the national standard of living. At the root of this progress was a substantial investment in research and development, along with a nationwide focus on excellence in science, technology, engineering, and mathematics (STEM) education and talent development (p.1).

This cold war logic and underlying culture of fear mongering politics that provides the political will to allocate considerable federal investment in public education, permitted the United States to further develop advanced manufacturing and supported a technology boom. "With growing international competition, the cost of inaction continues to grow at an intensifying pace" (p.1). The Department of Commerce echoed this message and stated that "Science, Technology, Engineering and Mathematics (STEM) workers drive our nation's innovation and competitiveness by generating new ideas, new companies and new industries" (Langdon, McKittrick, Beede, Khan, & Doms, 2011, p. 1). This report provides a series of statistics that are often cited in the broader justification of federal investment and national interest in STEM careers. For example,

- 1 in 18 workers were in STEM fields in 2010
- From 2008 – 2018, STEM job growth is predicted at 17.0 percent.
- STEM workers earn 26 percent more than non-STEM workers.
- Two thirds of STEM workers have college degrees

Altogether, this provides a rather powerful argument for the public and political support

for these initiatives.

However, it is worth noting that these visions and associated research claims benefit STEM employers who are looking for a better-trained work force without fully participating in the shared investment in the specific training required. Secondly, this creates the broader message, whether intended or not, that the purpose of schooling is to train a future work force, a utilitarian educational philosophy that is aligned with the pervasive neo-liberal ideology seeking reforms to benefit marketplaces. This dominant narrative disregards some of the more Jeffersonian perspectives for the role of higher education that are hard to find in the current educational policy contexts. This has the potential to further align industry with higher education to better meet the needs of corporations, without accommodating for the needs of learners beyond increasing potential access to projected careers that earn higher wages. While a good salary is an important component of quality of life, it is not a full realization of the possibilities of science education, democratic education and social justice (Zeidler, 2014). In response to widespread messaging on STEM education, the Humanities Commission from the American Academy for the Arts and Sciences (2013) argued the need for balancing and integrating expectations for higher education in order to meet the changing needs in a diverse political global landscape. Zeidler (2014) further critiques the current STEM education movement as a ‘deficit model’ and similarly argues that the arts and humanities are important components to a well-rounded STEM education.

While there is some debate as to whether or not we should be encouraging the rhetoric of the STEM pipeline, the Presidents Council of Advisors on Science and Technology (2012) (PCAST) notes that in order to address the issue of underdeveloped

STEM talent, especially from non-dominant groups, “better teaching methods are needed by university faculty to make courses more inspiring...and to create an atmosphere of a community of STEM learners”(p.1). The PCAST further explains that there are several significant challenges to transform college classrooms. For example, teaching faculty members often lack specific training in curriculum design that takes into account research on assessment, learning, and ways to engage students from diverse backgrounds. Additionally, these difficult pedagogical changes must occur within the institutional structures of post-secondary institutions that favor large introductory courses in the sciences that make student-centered learning a challenge.

This dissertation describes collaboration between college professors and instructors in the agricultural sciences, social sciences, and science education (me) to help design a supportive and engaging learning environment. In the list of jobs that are considered STEM careers, several fall under the category of Agriculture (e.g. agriculture engineer, food scientist, agriculture technician) according to the Department of Commerce (Langdon et al., 2011). Additionally, the content of the course requires learners to apply ecology, biology, chemistry, and physics, to address issues in land and resource management. For the purposes of this dissertation, I assume that sustainable agriculture *is* a STEM discipline and offer brief argument here that certain aspects of agroecological perspectives embedded in this course exemplifies a strong example of a science that is integrated with the humanities *and* aligned with a missing feminist perspective in dominant STEM disciplines. I aim to further justify agroecology as a Feminist - STEM (F-STEM) discipline here and later expand on what this might bring to the world of science education research in Chapter 3.

Agroecology: a Feminist Scientific Discipline?

Critical feminist researchers have offered heavy critiques of the underlying philosophy of sciences and the role science has played in concert with technology and engineering in the marginalization and degradation of human and natural resources (Calabrese Barton, 2001; Harding, 1991; Kleinman, 1998). Looking at the relationship between Science, Technology, and Society presents a number of poignant criticisms that are worth noting before blindly directing learners in the direction of STEM careers (Tan, Calabrese Barton, Kang, & O'Neill, 2013) . As previously mentioned, the global focus on STEM careers has the potential to reduce the role of the humanities and arts in the practice of science and associated decisions that are made in a democracy. Second, the assumption that preparing students of non-dominant backgrounds to assimilate into the hegemonic and patriarchal fields of science as a way to escape poverty while leaving the fundamental practices of environmental destruction implicit in our economy unquestioned is misguided and might contribute to further oppression of marginalized groups, especially from urban settings (Calabrese Barton, 2001) . Therefore, it is important to consider student interests and persistence in F-STEM disciplines that emphasize the values of multiple perspectives, local knowledges, diverse voices, and systems thinking, if we are to successfully and responsibly innovate in our current and future environment. Agroecology and work on sustainable and alternative food systems is an example of a feminist scientific discipline that requires a level of self-awareness and critical thought to support social transformation (Kloppenborg, 1991).

Sustainable agriculture and the science, practice, and social movement of Agroecology is a burgeoning scientific discipline that is inherently feminist, emphasizing deep, situated knowledge of landscapes and integrated systems perspectives to make decisions that balance environmental responsibility, economic viability, and quality of life for farmers and communities (DeSchutter, 2010; Francis, Breland, Ostergaard, Lieblein, & Morse, 2013; Francis et al., 2003; Gliessman, 2007; Gliessman, 2013; Guzman & Woodgate, 2012; Holt-Gimenez & Altieri, 2013; Molina, 2012; Vandermeer & Perfecto, 2013; Wezel et al., 2009). By feminist, I do not suggest it is “feminine, whatever that might mean” (Kleinman, 1998) but rather that there are aspects of feminist epistemology (Harding, 1991) that *should* be and often are embedded in the tool kits of its practitioners. In the growing movement of sustainable agriculture, some of the most troublesome actions are those that are taken without careful attention to local contexts, local/indigenous knowledges, or the voices and stories of women who are key to food sovereignty and sustainability (Patel, 2007; Vandermeer & Perfecto, 2013). It should also be noted that as a social movement, sustainable agriculture is female dominated, with women holding the majority of roles as practitioners, innovators, and leaders of organizations (Patel, 2007).

Dominant narratives in the agriculture sector position biotechnology and capital-intensive agriculture as keys instruments for *feeding the world*. The global population is expected to increase up to 9 billion by 2050 and there will be decreased access to arable land and fresh water. Climate variability will also complicate how we will produce enough food to feed a growing population. In the subtext of this narrative is the growing concentration of wealth and power in the hands of increasingly fewer farmers and

multinational corporations that are making critical decisions in the global food system. Often, the question of “how are we going to feed the world?” is asked rhetorically to point towards an industrialized food system and tools such as transgenic crops, capital-intensive machinery, and chemicals as the first and *only* empirically justified options to increase productivity on increasingly less tillable land. However, there is growing resistance that argues first that global hunger is mostly a question of *access* rather than *productivity* (DeSchutter, 2010). This is especially true in underdeveloped nations without readily accessible credit, land, water, or chemical fertilizers and other tools of the so-called ‘Green Revolution’ (Patel, 2007). Second, there is concern that the tools of industrial agriculture are pernicious consumers of fossil energy, fossil water (from ancient aquifers that are not recharging), and are leading to some of the gravest environmental problems such as anthropogenic climate change and the eutrophication and disturbance of aquatic ecosystems (DeSchutter, 2010; Kloppenburg, 1991; Kloppenburg, Hendrickson, & Stevenson, 1996).

Integrating Without Otherizing and Wicked problems

It is easy to dichotomize these agricultural practices through language like, Sustainable vs. Unsustainable, Ecological vs. Industrial, Low-input vs. High-Input, and so on. These divisions are part of what Derrida (1972) critiques as a western philosophical tendency to *otherize*, when it might be of more interest to see the confluence, or borderlands between concepts and groups. Failing to do so in the case of agriculture might stifle the innovation needed to make progress towards a more equitable food system in which *all* members have access to a culturally relevant and nutritionally adequate diet to support healthy human development.

One of the opportunities of sustainable agriculture education programs at LGUs is the chance to make larger scale change in how problems are perceived and addressed in the food system by using the institution's research, teaching, and extension branches (Jacobsen et al., 2012). Hamm (2009) outlines pragmatic, systems-based work that views agricultural sustainability and the health of a food system as more of a direction than a normative condition. He describes working towards a healthy, sustainable food system as tackling "wicked problems" because of a "range of complex interacting influences and effects; the influence of human values in all their range; and the constantly changing conditions in which the problems exist" (p. 241). In doing this challenging work, it is necessary to take a more holistic view towards the way that we educate future practitioners of agriculture and prepare consumers, policy makers, and resource managers to make decisions that have foundations in scientific principles but require a negotiation of values, morals and ethics that are embedded in individual voices and narratives. Further, addressing local and global issues of land management requires expertise in a number of different disciplines that operate under different paradigmatic assumptions that can generate tensions and lead to possible setbacks in productive collaborations. This dissertation explores the nature of these tensions during transdisciplinary collaboration more specifically in Chapter 2.

Socioscientific Issues and Decision Cases for Agriculture

Science education researchers have developed a robust, research based socioscientific issues (SSI) framework to engage learners in scientific practices through compelling real-world issues (Presley et al., 2013; Sadler, 2011; Zeidler, Sadler, & Simmons, 2005). At the University of Minnesota, Stanford, Crookston, Davis, and

Simmons (1992) developed curriculum that uses what they call “decision cases for agriculture” that are based off of a framework used at the Harvard School of Business. For this course, we used the general approach of Stanford et al., finding real-world farming situations, but made attempts to integrate compelling SSIs (such as soil degradation, climate change, weed resistance in genetically engineered crops) into each of the teaching cases. Before this dissertation, none of the instructors involved in the collaboration had ever used SSI or decision making teaching cases as part of their practice. As mentioned earlier, PCAST (2010) highlighted some of the challenges with training college professors in research based science education pedagogical strategies. This dissertation applies the SSI framework and a “wicked problems” perspective in collaboration with professors from diverse agricultural science disciplines to create and study engaging learning experiences that allow students to practice making management decisions that balance values of environmental responsibility, economic viability, and social justice.

Theoretical Frame

The three manuscripts feature a theoretical frame that integrates situated learning theory (Lave & Wenger, 1991), communities of practice (Wenger, 1998; Wenger et al., 2002), and identity and agency in cultural worlds (Holland et al., 1998). All of these theories share a common foundation in social activity theory and sociocultural learning theories that aim to describe the ways in which individuals in social and cultural contexts make meaning and take action. An underlying ontological assumption for all three theories is that all meaning is socially and culturally co-constructed through a process of *becoming* or assuming particular *identities* and that it is through this participation in

social contexts that individuals, groups of people, and the world, change. These theories focus research endeavors that aim to describe how people are changed by their interaction in social and cultural worlds, as well as how those social and cultural worlds are changed by individual actions and practices. Below, I briefly describe each of these theories but emphasize the notion of identities as products of, and potential barriers to, learning in local and global communities. I go on to briefly review literature in STEM Identities (Tan & Calabrese Barton, 2007; Tan et al., 2013; Wager, 2014) and equitable science assessment (Fusco & Barton, 2001; Siegel, Wissehr, & Halverson, 2008) and explore how to leverage this notion of identity formation to better envision assessment practices to help support learners come to feel as if F-STEM disciplines, like agroecology, are *for* them.

Situated Learning Theory

Lave and Wenger (1991) present the concept of situated learning through, “legitimate peripheral participation,” and describe learning as being, “configured through the process of becoming a full participant in sociocultural practice” (p.29). According to Lave and Wenger, this theoretical lens, “subsumes,” the acquisition of “knowledgeable skills” within a “social process” (p. 29). Learning occurs through participation in communities of practice that share a common language, set of values, or shared enterprise. Situated learning provides additional dimensions to explore when trying to understand how learning occurs that goes beyond curriculum or learning goals within a classroom setting. For example, situated learning theory helps problematize the belief that, “intentional instruction [is] in itself the source or cause of learning,” and brings attention to the fact that often, “what gets learned is problematic with respect to what is

taught.” In other words, it provides a view of learning that helps better understand how learners make meaning of the work that they do in school settings, and clarifies how this might lead to changes in *who* they are. Alternatively, it might highlight ways that learners are constrained by who they think they are, an idea that is later expanded upon by theoretical contributions of Wenger (1998) and Holland et al. (1998). While it is valid to focus on cognitive or skill-based aspects of a community through a lens of situated learning, I focus more attention to the processes of identity formation and the opportunities that situated learning provides to describe the political, cultural, historical and situated context of a learning community, though all of these aspects are intimately connected. Lave and Wenger explain that “we think it is important to consider how shared cultural systems of meaning and political-economic structuring are interrelated, in general and as they help to coconstitute learning in communities of practice” (p.54). This is especially useful in exploring the political ecology of education that aims to witness the interconnections of these forces as they ultimately relate to resource management and studies of marginalization (Meek, 2014).

One of the other affordances of situated learning is that it provides a viewpoint to examine the roles of the course participants and issues of power and access to resources that are central to political ecology. For example, Lave and Wenger argue that *all* members of a community of practice are experiencing their own process of becoming, that is, they are *all* learning. This is different than what Freire derides as the “banking method” of education that assumes instructors are the experts who are making *deposits* into the empty accounts in students’ minds, with a flow of information and resources going from an expert to novice (Freire, 1990). Situated learning, however, is not an

instructional model, but instead guides researchers to understand that learning is often multi-directional. This is particularly useful as I consider the ways that instructors learn from their students in all three research articles.

Communities of Practice

Wenger (1998) further describes a process of identity formation through participation, membership, and meaning making in a community of practice. In the dissertation, I am particularly interested in applying this framework to understand how participants in the course exhibit “identities of participation” and “identities of non-participation” in the classroom and broader social movement of sustainable agriculture and agroecology.

While Lave and Wenger repeatedly argue that situated learning is *not* a pedagogical strategy or curriculum framework, Wenger (1998) and Wenger et al. (2002) explain the theoretical basis of communities of practice can be used to design learning environments in diverse educational settings in schools and the private sector. This vision of educational communities centers on this idea of “opening identities” and explains, “identity formation is a lifelong process whose phases and rhythms change as the world changes” (p. 263). Again, instead of thinking of the classroom as a site where only the students are the ones learning, this view of education seems particularly appropriate considering the ongoing need for *all* members of the learning community to be able to assume new identities, or ways of being in the world. Table 2 highlights Wenger’s “Dimensions of educational design” and sample guiding questions for education designers related to each component. This topic will likely form a future manuscript, but

for now, please see the course syllabus in Appendix 1, to see how these dimensions are evidenced in the course.

Table 1: Dimensions of educational design. Created from Wenger (1998)

Dimension	Description	Guiding Question
Participation and reification	<ul style="list-style-type: none"> • How much to reify learning, its subject and its object 	<ul style="list-style-type: none"> • What forms of participation can be designed that do not require reification of the subject matter beyond what is already part of the practice?
The designed and the emergent	<ul style="list-style-type: none"> • The relation between teaching and learning is not one of simple cause and effect 	<ul style="list-style-type: none"> • How can we maximize the processes of negotiation of meaning enabled by that interaction?
The local and the global	<ul style="list-style-type: none"> • Educational experiences must connect to other experiences 	<ul style="list-style-type: none"> • How can we enable transformative experiences that change students' understanding of themselves as learners and thus their ability to move among practices and learn whatever they need to learn where they are?
Identification and negotiability	<ul style="list-style-type: none"> • There are multiple perspectives on what an educational design is about: its effect on learning depends on inviting identities of participation 	<ul style="list-style-type: none"> • For whom is the design an opportunity to build an identity of participation?

Identity and Agency in Cultural Worlds

Holland et al. (1998) present another dimension to sociocultural learning theories and synthesizes research on identity from critical and feminist theoretical perspectives as it relates to social change theories and empirical work in cultural studies. Like situated learning and communities of practice, Holland et al. elevate the importance of stories in the making and remaking of identities. Further, they crystalize two interrelated concepts – *figured worlds* and *improvisations* – that are applied throughout this dissertation research related to identities. According to Holland et al., “figured worlds could also be called figurative, narrativized, or dramatized worlds,” that individuals construct and by which they might be constrained (p.53). They also outline how these figured worlds are created and might change over time:

The production and reproduction of figured worlds involve both abstraction of significant regularities from everyday life into expectations about how particular types of events unfold and interpretation of the everyday according to these distillations of past experiences (p.53).

For example, in this dissertation we might tell stories about the figured worlds of ‘academia’, ‘sustainable agriculture’, ‘science education’, or ‘education politics’ that are based on some combination of experiences with distal or central aspects of these constructed social spaces that can have very tangible affects on how one acts.

Improvisations are the performances that all individuals embody while trying to negotiate a variety of figured worlds. I use the concepts of figured worlds and community of practice interchangeably because both emphasize the belief that individuals and society ascribe the rules of participation within specific or imagined groups that do not

necessarily have to be bound to a physical space. There are innumerable figured worlds that we negotiate in daily life, and there are constant improvisations or experimentations that individuals enact in movements of agency and oppression. As a researcher, these improvisations are rich sources for understanding how learners and social groups embody or fail to embody specific identities in response to the otherwise invisible social and cultural forces.

STEM Identities

There has been significant work that comes from the field of science education to help understand the nature of a leaky STEM pipeline (Maltese & Tai, 2011; Mark et al., 2013). Some of this research focuses on the experiences of women and other underrepresented groups in formal and informal learning spaces (Calabrese Barton & Tan, 2010; O'Neill & Calabrese Barton, 2005; Tan et al., 2013). Students from non-dominant groups tend to lose interest in these STEM careers for a variety of reasons. However, this research suggests that what is most concerning is that students have come to learn that science is not *for* them (Basu & Calabrese Barton, 2007; D. Birmingham & Calabrese Barton, 2014; Calabrese Barton, Ermer, Burkett, & Osborne, 2003; Calabrese Barton & Tan, 2009; Calabrese Barton & Tan, 2010; Fusco & Barton, 2001; Mallya, Mensah, Contento, Koch, & Calabrese Barton, 2012; O'Neill & Calabrese Barton, 2005; Tan & Calabrese Barton, 2007, 2010). In other words, especially for the most marginalized groups in STEM careers in the US (i.e. women, African Americans, Latinos/Hispanic, Native Americans) they are not only less likely to pursue careers in STEM compared to white, male counterparts, but growing evidence suggests that their learning experience and external environment make it difficult for them to identify with

science. They might be unable to view science as relevant to the limitless decisions that they will make as global citizens and may not consider science a feasible career path. However, interventions in both formal and informal settings have shown promising practices that help support science identity formation (Birmingham & Calabrese Barton, 2014; Birmingham, 2013; Fusco & Barton, 2001; Mallya et al., 2012; O'Neill & Calabrese Barton, 2005; Tan & Calabrese Barton, 2007, 2010). This work highlights the importance of building an anchor point, or *hybrid space* between the world of science, school, and home to engage learners in science practices that leverage students' *funds of knowledge* (Calabrese Barton & Tan, 2009). Further, empowering voices of marginalized learners and telling their stories of experiences in science settings have opened up spaces for alternative ways to represent science achievement and help students realize that science can be *for* them (Birmingham & Calabrese Barton, 2014; Calabrese Barton & Tan, 2009; Fusco & Barton, 2001; Mallya et al., 2012; O'Neill & Calabrese Barton, 2005; Tan & Calabrese Barton, 2010; Tan et al., 2013). This work tends to engage mostly urban learners through ownership and active participation in equitable transformation of their environment using the tools, discourses, and practices of science (Calabrese Barton et al., 2003; Mallya et al., 2012; O'Neill & Calabrese Barton, 2005; Rahm, 2002).

This research from a critical feminist science education perspective provides important groundwork to figure out how to help support the diverse needs of the most marginalized learners as they take pathways through the STEM pipeline. Birmingham (2013) fills a previous gap in the literature by sharing the voices of non-dominant students in an after school setting with the students' teachers to provide space for open dialogue to support pedagogical change. In this dissertation, I aim to further connect what

has been learned about supporting science identities through this vast work in critical and feminist science education with research on assessment and instructional decision-making and as a researcher bridge connections between student voices and college instructors.

Equitable Science Assessment Practices

In the third chapter, I focus on a philosophical dilemma facing science educators regarding the purposes of science assessments. There has been a call from many in the field to open up spaces for alternative ways to document, perform, or enact science learning that extend beyond high-stakes standardized tests (see for example Fusco & Barton, 2001). There is also concern that for many teachers and students, assessments are just scientific instruments used to categorize or evaluate students and provide accountability (Pellegrino, 2012; Pellegrino, Chudowsky, & Glaser, 2001). Concern about this narrowed purpose is not new and there is growing emphasis in the area of research on equitable assessment in science education. Research in this area comes from various paradigmatic orientations and largely focuses on meeting the needs of English language learners (Lee, Quinn, & Valdes, 2012; Lyon, Bunch, & Shaw, 2012; Siegel, 2007; Siegel et al., 2014; Siegel et al., 2008), establishing concern regarding cultural validity (Solano-Flores & Nelson-Barber, 2001; Wolf, Farnsworth, & Herman, 2008), supporting teachers as they learn about alternative assessment practices (Lee, Lewis, Adamson, & Maerten-Rivera, 2008), and using assessments as a way to share authority around what counts as science achievement (Fusco, 2001; Fusco & Barton, 2001).

In this dissertation I hope to clarify this work and begin building a framework of Equitable Science Assessment Practices (ESAP). Previous research emphasizes the

importance of classroom-level assessments (Siegel, 2007), formative and responsive assessments (Lyon, Siegel, Furtak, Menon, & Shaw, 2014), and alternative assessments (Fusco, 2001; Fusco & Barton, 2001; Lyon et al., 2012; Mamlok-Naaman, Hofstein, & Penich, 2007) to support learning and enhance instructional decision making in formal and informal science learning environments. These practices in equitable assessment are not exclusively for English Language Learners or other marginalized groups, as they have shown to support academic achievement for native speakers (Siegel, 2007; Siegel et al., 2014; Siegel et al., 2008). Enacting ESAP requires a complex system of knowledge and practices embedded in local knowledge of learners, diverse scientific disciplines, and unique sociocultural institutional contexts that I describe in both Chapter 2 and Chapter 3.

The previously mentioned empirical studies that explore this notion of supporting scientific identity formation tends to focus on broad “science identities” in connection to STEM career trajectories (Tan & Calabrese Barton, 2007; Tan et al., 2013). However, each science discipline has an associated but ever changing set of values, discourses, skills and practices that make it unique. Therefore, there are specific cultural, political and economic factors that interact in complex ways as students consider career pathways. This is especially true for the field of sustainable agriculture. This interaction and negotiation of these forces should be further clarified to fully understand the nuances of pursuing a particular STEM career and the role of identities in this decision making process.

Purpose of Dissertation

So far in this chapter I have provided some broad historical, conceptual, philosophical, pedagogical, and theoretical features of the rationale for this dissertation study. In review, this dissertation applies political ecology to guide educational research in an upper-level sustainable agriculture course in a LGU that was collaboratively constructed using a decision making curricular framework that integrates regional agriculture issues. I started out this chapter with an excerpt from an instructor planning meeting where Helen described this work as *flying*. Here, I argue instead that we were *improvising*, as people always do in light of the physical, political, and cultural structures in which they operate (Holland et al., 1998). There is always this sense of negotiating who one is, where one is, and how others think one should act that results in actions that are taken in many different figured worlds. It is not as simple as just making things up as we go, because this improvising needed to make sense within the figured worlds of academia, the LGU, and science education research communities that I occupy. Therefore, my improvising with a team of instructors was meant to simultaneously support the teachers and students in the enactment of assessment practices while learning to better understand the process of designing sustainable agriculture education curriculum in a community of practice, and further explore the ways learner identities are shaped in the process of this participation. Understanding how assessment practices can be utilized to support identities of participation in this scientific community of practice can help further merge previous research in critical feminist science education on STEM identities and equitable science assessment.

The purpose of this dissertation is to apply a variety of qualitative research methodologies to (1) explore the sociocultural tensions that were experienced when designing and enacting this undergraduate curriculum in agroecology, (2) identify aspects of science assessment practices that support F-STEM identities, and (3) enact reflexivity to elaborate ways learners and researchers come to develop identities of participation within a community of practice.

To achieve these purposes, I present three research articles that are each guided by separate research questions and are meant to stand-alone. The second chapter is an article targeted at the journal, *Agriculture and Human Values*. This article applies case study methods (Stake, 1995) and focuses on the following research question: In what ways does the course community of practice encounter sociocultural tensions while enacting sustainable agriculture decision-making cases? The third chapter features an article intended for the *Journal of Research in Science Teaching*. This article uses iterative qualitative methods (Coffey & Atkinson, 1996) and poetic representation (Ward, 2011) to learn from the experiences and voices of three women in the course. I explore the following questions: (1) How can women's identities in and outside of F-STEM courses be used to clarify features of Equitable Science Assessment Practices? (2) What are assessment features that support the formation of F-STEM identities? While working on the second and third chapter, I became interested in this notion of *mapping rhizomes* as described by the poststructuralists Deleuze and Guattari (1987). Other political ecologists, like Laura Ogden (2011) have experimented with *mapping rhizomes* to support ethnographic writing and analysis. I found this concept extremely valuable throughout my dissertation but try to connect mapping rhizomes to reflexivity (Finlay,

2002) in qualitative research. I prepared my third manuscript to submit for the journal, *Qualitative Research*, and demonstrate how both mapping and reflexivity can be used in relationship to identities and membership within a community of practice. For this fourth chapter, I answer the following question: how can reflexivity be practiced through mapping rhizomes to uncover barriers to community membership in narrative social change research? In the second, third, and fourth chapter, the reader will notice that I have decided to use the pronoun ‘we’ instead of ‘I’ because these chapters will be submitted for publication with feedback and ideas from additional authors.

Motivations for the Study

All of the learning and work embedded in this dissertation was motivated by the known and unforeseen global challenges that we face regarding the short-term and long-term management of Earth’s natural resources to support diverse human ecological systems. I am trying to gain the self-awareness and social connectedness to initiate modifications to the broader oppressive structures of society that are resilient to change. In general, I aim to better understand who am I, where I am, and what to do in order to reconstruct a more equitable, sustainable society. I simply cannot imagine *trying* to do anything else through my teaching and research. Any such attempt to, “save the world,” assumes that (1) the world needs saving and (2) somehow I am positioned to do any type of remediation without somehow, through my actions or inactions, diminishing quality of life for others. However, through my willing participation in pervasive industrial cultural practices that help concretize a global trajectory of runaway climate change, expand free-market capitalism, and harden the hammer of neo-liberal ideology, I am complicit in the ongoing degradation of natural resources and marginalization of global populations. This

is simply part of the context in which this dissertation unfolds and a byproduct of my privileged position as a (mostly) white, middle class, male from the post-industrial United States. At times during this study I have had to silence or efface the identities that can be inferred through provocative statements such as these. I have come to learn to be strategic when unveiling what could be polarizing aspects of who I am as a researcher and educator. However, in identifying the assumptions of this study, I feel compelled to make these underlying motivations transparent to the reader.

Limitations of the Study

This dissertation study has a number of limitations that are reflective of a relatively small number of participants who were studied primarily during a fifteen-week semester. The participants and the course under study was a sample of convenience and largely under study because of my involvement in helping create, evaluate and teach the course. My intimate connection to the teaching and research, as well as a close relationship that I developed with a number of the participants in the study, presents a number of limitations because of the many different roles I have played and my proximity to the course. In each of the manuscripts, I have described the attempts made to enhance validity and trustworthiness.

The findings from this type of qualitative research are not meant to be generalizable because they are more representative of the unique context in which this study takes place. Readers are meant to benefit from the thick descriptions of participants and the case to decide for themselves what transfers to different contexts or resonates with their own research or teaching. With limited space in the manuscripts geared toward specific journals, I made difficult decisions regarding the representation of findings and

the types of analysis. There are a number of additional studies that I hope to conduct based on the data collected for the dissertation study, which I will later discuss in my conclusion chapter.

When possible, participants were involved in reading through drafts of manuscripts and helped confirm my interpretations of their experiences in and outside of the course. I am especially indebted to Margaret, Heather, and Mike (pseudonyms) for their willingness to make sense of this work. However, there are a number of other participants who were not reachable, not interested, or never recruited to help in confirming my analysis, representations, or interpretations. Before submitting for journal publication, I intend to enlist more help from participants to enhance my ability to share their experiences in the course with a broader audience.

Another significant limitation of this study is that it involves only a superficial exploration of issues such as gender, race, or socio-economic status as they relate to the research contexts. In some cases data on these dimensions were not officially collected, examined, or considered because they were not part of the original conceptualization of the study. I hope to include a more thorough treatment of these essential dimensions of my collaborators realities and identities in my future work.

Lastly, although my study lays out a desire to use political ecology to understand the ways that LGUs are connected to land management and environmental issues, the study is severely limited in terms of connecting classroom curricular decisions to real life management practices and resulting ecological problems. In the future, it might be possible to consider a longer-term study that followed learners from course work in

LGUs to real world farm management settings to see a more direct connection between teaching practices and resource management.

CHAPTER 2: WICKED PROBLEMS IN A SUSTAINABLE AGRICULTURE COURSE: A CASE STUDY

Introduction

Scholarship in sustainable food systems aims to address a variety of environmental health problems that intersects with the natural resource management to produce, process and distribute food. Kreuter, Rosa, Howze, and Baldwin (2004) describe these types of challenges as *wicked problems* because they are culturally and politically embedded in ever changing contexts and lack simple answers. Hamm (2009) suggests that *wicked problems* in the food and agriculture system cannot be addressed using expert authority alone because of the “range of complex interacting influences and effects; the influence of human values in all their range; and the constantly changing conditions in which the problems exist” (p. 241). This does not mean, however, that progress cannot be made towards a more sustainable food system, but doing so entails a unique approach that is locally integrated, takes advantage of community relationships, and is ecologically and culturally diverse (Hamm, 2009). Political ecologists (Robbins, 2004) as well as political agroecologists (Molina, 2012), have levied a similar claim that to equitably enact solutions to environmental and human health issues connected to our food system, empirical research should be grounded in deep local knowledges that accommodate diverse stakeholder perspectives. Learning how to leverage, describe, and make decisions using this type of local knowledge is challenging but important work for agroecologists and sustainable agriculture educators.

In this paper, we use case study methodology to describe the integration of this wicked problem philosophy into the design of an upper-level sustainable agriculture course at a Large Midwestern Land Grant University (LMW LGU). We start by situating

this research within previous literature in sustainable agriculture education and science education to build an empirical framework we used for our course design. We argue that doing this work of developing and enacting sustainable agriculture education is in itself a wicked problem and describe the conflicts and tensions related to the identities of participants that arise within the local and global learning communities engaged in the practice of sustainable agriculture education.

Course Framework

Sustainable Agriculture

Courses in sustainable agriculture should help learners envision and participate in the production of food, fiber and fuel that balances values of environmental responsibility, economic viability, and farmer and community quality of life. Practicing sustainable agriculture means making resource management decisions that require balancing tradeoffs in this triple bottom line, in a particular local context. DuPuis and Ball (2013) demonstrate the value of undergraduate learning experiences that emphasize the ‘how’ not ‘what’ of sustainability. Instead of describing a collection of facts or criteria that can be used to normatively judge something as *sustainable* or *unsustainable*, our course was designed to provide experiences for students to assume different roles within the food system to learn *how* to practice sustainable agriculture. We often described sustainable agriculture as “a direction not a destination,” to move students away from the tendency to polarize discussions or categorize practices without taking into account broader considerations or contextual limitations.

Agroecology

We assume that sustainable agriculture and agroecology are interrelated and exchangeable terms, though it is helpful to elaborate some details regarding a few principles of agroecology. Agroecology is described by Gliessman (2007) as *the science of sustainable food systems*, or *the ecology of food systems* (Francis et al., 2003). Wezel et al. (2009) synthesize the history of agroecology as a combined *practice, science, and social movement*. Agroecology takes a systems perspective to better understand how to enact practices that manage ecological resources to generate agricultural products, support human livelihoods, and maintain healthy ecosystems. The science of agroecology treats the farm as an ecosystem and relies on ecological analytical tools to seek deep, contextualized knowledge of a farm ecosystem, while also seeking generalizable knowledge that applies in diverse global contexts (Vandermeer & Perfecto, 2013). This *local/global* epistemological tension is important to consider when designing learning experiences in sustainable agriculture. Other tensions arise because agroecology is viewed as social resistance to conventional industrial practices and agricultural sciences that agroecologists critique because of the role that these practices and perspectives play in degrading natural and human resources. There are also concepts like *civic agriculture* (Lyson, 2004) and *foodshed work* (Kloppenburg et al., 1996) that are all part of what we consider to be the same social movement, set of practices and empirical work that encourages intentional social participation in the political and ecological act of farming and eating. While there is some debate within the discipline, Wezel et al. argue that all three of these factors (science, practice, and social movement) must be present and balanced to fully represent agroecology. Further, Molina (2012) makes the case that

agroecology should also consider the broader political economy when making ecosystem management decisions. In this study we use the terms agroecology education and sustainable agriculture education to describe our curricular and pedagogical focus on enhancing local/global student knowledge *of*, and participation *in*, agricultural resource management that values environmental, ecological, and social responsibility.

Research from Sustainable Agriculture Education

At the 2011 Sustainable Agriculture Education Association Conference, representatives from LGUs with sustainable agriculture programs documented their shared opportunities and challenges (Jacobsen et al., 2012). One of the group's findings was the importance of program identity to encourage community building. However, they describe possible challenges that might arise related to language. For example, using the term, "'sustainable' could invoke the implication that previous programming was 'unsustainable' to public stakeholders and colleagues within the LGU" (p. 7).

Agroecology programs are strategically positioned within LGUs that hold a three part mission of extension, research, and teaching and offer a significant opportunity to better engage learners in problems that local farmers are experiencing using the best available research and expertise. However, there are inherent challenges developing the program identity on campuses with well-established connections to commodity groups and industry. In this study we explore the nature of this tension as experienced by the students and instructors in this Advanced Practices of Sustainable Agriculture (APSA) course at the LMW LGU.

Designing curriculum for a sustainable agriculture course is an endeavor that many other researchers and educators have described (Clark, Byker, Niewolny, & Helms,

2013; Feenstra, 2002; Charles Francis et al., 2013; C. Francis et al., 2003; Jacobsen et al., 2012; Damiann M. Parr & Horn, 2006; Damian M. Parr, Trexler, Khanna, & Battisti, 2007; Trexler & Saunders, 2003). We use this literature to build a framework for designing learning experiences to engage a diverse student population. Over the past thirty years, researchers have elevated several important features for meaningful student learning experiences. Charles Francis et al. (2013) describe the importance of grounding learning experiences in real world regional farm problems to help students apply concepts in situated contexts with the help of faculty members from different disciplines. Galt et al. (2013) document work at the University of California at Davis that encourages social and individual transformation and focuses on creating a *student-centered* learning community. Waldenström, Salomonsson, Francis, Moulton, and Lieblein (2008) describe a framework and philosophy for a bachelor's degree that is specifically suited to individual student interests in agroecology. Altogether, this work has inspired the transformation of our APSA course to better engage students in authentic and reflective practice of sustainable agriculture anchored in regional, real world farming challenges aligned with individual student interests.

Research from Science Education

Research in science education provides two useful constructs that contributed to the design of this course. First, there has been significant interest and advancement in socioscientific issues (SSI) based teaching and learning to engage learners, support science achievement, and enhance student socioscientific reasoning skills (Presley et al., 2013; Sadler, 2011; Sadler, Barab, & Scott, 2007; Zeidler et al., 2005). We found it helpful to think of SSI as under the umbrella of Problem-Based Learning (PBL)(Albanese

& Mitchell, 1993), which many of our collaborators and students were familiar with. Historically, other curriculum movements, like Science, Technology, and Society, aimed to draw connections between the ways these components of modern civilization interacted, which we argue is especially relevant in discussions of agriculture. However, both PBL and STS have become watered down or imprecise terms that researchers like Zeidler, Sadler, and Simmons (2005) aimed to supplement with SSI in order to enhance empirical progress. Some key features of SSI instruction that we applied were anchoring the learning in a compelling issue that is featured in the beginning of a unit or lesson to enhance the relevance of scientific principles. Later, students also had an opportunity to practice making some type of decision based on scientific evidence and moral and ethical reasoning. This helps students form arguments that includes multiple perspectives and considerations of the nature and philosophy of science (Presley et al., 2013; Sadler et al., 2007). We believe these outcomes are important for practitioners of agroecology and integrated this SSI framework into our course.

Second, critical feminist science education research has summarized the challenges of engaging *all* students and has offered significant contributions related to the formation of scientific identities. This research focuses on learners typically marginalized in science classrooms (e.g. African American/Latino, low SES, females) and elevates the problem of students feeling as if science is not *for* them (Calabrese Barton et al., 2003; Calabrese Barton & Tan, 2009). That is, students feel as if science is not relevant to their daily lives or they are not able to pursue careers in disciplines like agriculture, which are based in the sciences (Tan et al., 2013). This research shows the importance of valuing student voices (Birmingham & Calabrese Barton, 2014), encouraging ownership (O'Neill

& Calabrese Barton, 2005) and taking into account students' funds of knowledge (Calabrese Barton & Tan, 2009; Fong & Siegel, 2005) encourage scientific identity formation. As researchers in equitable science assessment practices, we are also trying to find ways to support and describe this process of learner identity formation. This manuscript is a subsection of a larger research project that explores how to best support identity formation through assessment and instructional practices in agroecology courses.

Theoretical Perspectives in Sustainable Agriculture Education

While not always evident, the sustainable agriculture literature tends to emphasize sociocultural and social constructivist theoretical perspectives. For example, many programs often feature a student farm as a core component of their curricular emphasis on hands-on, or experiential learning (Dewey, 1938; Parr & Horn, 2006). Parr and Van Horn explain that while students consistently call for and benefit from this *learning by doing*, it is important to fully realize the promise of experiential learning theory to engage learners in compelling issues that provide a “sense of purpose” and are “linked to an iterative cycle of reflective observation, abstract conceptualization, and experimentation” (p. 430). Parr et al. (2007) conducted a Delphi study to determine key components for sustainable agriculture programs. Notably, they describe the need for a blend of social and natural sciences and the importance of coordinating with regional producers and stakeholders to expose students to a variety of roles within the food system. Parr et al. and others (e.g. DuPuis & Ball, 2013) also emphasize the importance of sociocultural perspectives of learning that move beyond experiential learning. However, researchers in sustainable agriculture have yet to describe how sociocultural views of learning like situated learning theory (Lave & Wenger, 1991) and communities of practice (Wenger,

1998; Wenger et al., 2002) can inform design and research of these learning environments. We hope this manuscript makes this important contribution to the field.

Situated learning is a sociocultural learning theory that explains learning as a process of becoming a member of a community of practice (Lave & Wenger, 1991). In this view, learning is less about assimilating specific bits of information and more about attaining a value system, language, and norms of behavior of a given community that shares a common practice. Lave and Wenger pursued this research when looking for alternative learning contexts outside of schooling and also looking for a way to explain the role of learning in association with the sociological question of how civilizations change over time and the importance of power in social learning contexts. Wenger (1998) went on to clarify his ideas around communities of practice and asserts that assuming different roles within a community of practice and meaningfully contributing to the group can impact the identity of that community and the identities of the individuals within that community. In doing so, all learners who are part of the community are simultaneously changing themselves, the group, and society through a variety of *identity trajectories* (Wenger, 1998).

McGuire, Morton, and Cast (2013) developed an informal community of practice of Iowa row crop farmers sharing a watershed. They found that participation in this community setting helped the participants assume what they called “good farmer identities,” and adopt practices that reduced fertilizer runoff into waterways. Education researchers that explore these identity trajectories present theoretical models that display a set of trajectories or tracings of affinity towards science careers (for example) on the y-axis and time on the x-axis (Jackson & Seiler, 2013). They argue that over time, students

tend to follow paths towards (positive direction) or away from science (negative direction). This path can be portrayed as linear but it is really the line of best fit that summarizes the changes in an affinity towards a local and global science community of practice.

We propose, however, that a community of practice might be represented as a sphere and that individuals, like particles, negotiate their affinity or repulsion from a community sphere over time. In this way, the identity of the community can be described as the collective values associated with members of the community and individuals are transformed as they learn to assimilate or adhere to this value system. In this paper, we explore ways to observe the values associated with a particular community of practice by describing the nature of the sociocultural tensions experienced within communities. The way that these sociocultural tensions or forces act upon individual identities and the community identities are telling in terms of power within that community and the relative position of a local community of practice within a regional and global community of practice.

It is noteworthy that situated learning and communities of practice are learning theories that are meant to be descriptive rather prescriptive. However, others (Chang, Chen, & Ki, 2008; Wenger, 1998; Wenger et al., 2002) have extended this community of practice work to design education systems. This position aligns well with versions of critical pedagogy and democratic education (Freire, 1990, 1991; Spring, 1994) that are called for by researchers and curriculum designers in sustainable agriculture education (DuPuis & Ball, 2013; Galt et al., 2013). These pedagogical philosophies assume that the purpose of education is not the accumulation of ideas or facts but instead fundamental

abilities to participate in the work of actively transforming civilizations through participation as a responsible citizen when the existing structures fail to address current needs (Galt et al., 2013). We agree that agroecology education should align with this purpose and believe studying identity and community of practice tensions and transformations is a way to support local and global sustainable development through education.

Methodology:

This case study research is informed by Stake (1995) and focuses on the process of developing and implementing curriculum informed by the previously reviewed literature. We focus on what we call *teaching units* that were developed and implemented in an undergraduate course. Our case is bounded by the participants involved in the creation and enactment of APSA, during the summer and fall of 2013. Using Stake's categorization, this work is an *intrinsic* case study because we "need to learn about [this] particular case" (p. 3). This case study methodology provides an opportunity to understand the depth of the present case while also applying relevant theoretical and philosophical principles to local and global issues of practice in sustainable agriculture education.

Our case study began during the summer of 2013 as the team of instructors worked to develop the course philosophy and curricular framework. While the course development process started before June of 2013, this is only briefly considered as part of the historical context of the case, and does not fall within the bounds of the case of study. The actors in this case study assumed various roles as instructors, content experts, farmers, students, and learners. Often, these roles were held simultaneously by individual

actors and varied depending on the situation. For the purposes of this study, we focus primarily on experiences of instructors (Table 1) and students (Table 2) participating in the course, and do not include analysis of farmers and experts that were not also instructors or students. We have used pseudonyms for all of our participants. With the input of all learners in the community, the teaching units focused on decisions in regional settings and situated students in different roles throughout the agroecosystem to practice balancing values of environmental responsibility, economic viability, and quality of life.

Table 2: The instructors in the case. Includes their institutional roles, role in course and key areas of expertise

Instructors	Institutional Role	Role in course	Areas of expertise
Helen, PhD*	Assistant Professor	Lead instructor	Local food systems, consolidation in agriculture
Peter, PhD	Emeritus Professor	Co-instructor	Dairy Science, Pasture-Based Grazing
Chris, PhD Candidate*	Graduate Research Assistant	Co-instructor	Urban Agriculture, Science Education, Teacher Education
Mark, PhD	Adjunct Professor	Co-instructor	Agronomy, Diverse Cropping Systems
Kyle, PhD	Adjunct Professor	Co-instructor	Soil Microbiology, Weed Science
Henry, PhD	Emeritus Professor	Co-instructor	Rural sociology, consolidation in agriculture, conservation tillage

*Authors

Table 3: The students in the case. Includes major, year in school and key agricultural experiences

Students (n=13)	Major	Year	Food System Experiences
Melissa	Animal Science	Senior	Raised on large family row crop, cattle, and hog farm
Carl	Agriculture Economics	Senior	Family farm, employee at fertilizer and chemical company.
Lance	Agribusiness	Sophomore	Family row crop farm and agricultural services company
Travis	Environmental Science	Sophomore	Family building hobby cattle farm
Glenda	Sustainable Agriculture	Senior, non-traditional	Raised on diverse farm, goat herd management, and pasture-based dairy
Paula	Sustainable Agriculture	Senior, non-traditional	Worked in large retail grocery store
Mike *	Nursing	Non – Degree Seeking	Internships in Urban Agriculture
Margaret *	Food Science**	Senior	Summer work experience in organic vegetable production, Soil judging
Allison	Anthropology**	Senior	Research experience field work with South American farmers and vegetable farm, and urban farm internships
Nate	Sustainable Agriculture	Senior	Internships on small vegetable farm
Carlo	Agriculture	Sophomore, international Student	Plant breeding research
Patrick	Agriculture Economics**	Senior	Restaurant line cook, urban agriculture internship
Heather*	Sustainable Agriculture	Senior	Summer small, diverse farm internships, urban agriculture

*Helped review and confirm findings from case study

** Sustainable agriculture minor

The key issue we are interested in is the way that these actors in this community of practice encounter and navigate sociocultural tensions while enacting the reformed curriculum. While it would have been possible to collectively explore and compare the development, enactment, and refinement of each of these teaching units in a multiple case study, we chose instead to define the case as the entire course, because the actors, context, and key issue are consistent throughout these teaching units. In our findings, we constructed vignettes based on the enactment of three units because they simultaneously convey thick descriptions of the work done by actors in the course and provide evidence of the variety of sociocultural tensions that the actors encountered.

Murakami and Hendrickson are actors in the case study and the first and second authors of this manuscript. Murakami approaches this work as an urban farmer, science education researcher, and instructor in the course. These multiple roles allow insight into the course development process and his intimate knowledge of the case is viewed as an asset rather than a limitation. Hendrickson adds to the validity of the study because her perspective as instructor of record offered multiple opportunities for reflection and confirmed interpretation of findings. This embedded participant-observation allowed for rich sources of data that were used to construct the representations of our case and validate our collective analysis. Siegel contributed not only expertise as a science education scholar, but also provides an external analytical view of the interpretations of the other authors. Together, we explored the following research question: In what ways does the course community of practice encounter sociocultural tensions while enacting sustainable agriculture decision making cases?

Data Collection

Throughout the course, Murakami took primary responsibility for data collection and management. During the planning phase of the course, beginning in June of 2013, meetings between collaborating instructors were audio recorded. In early August, all of the course instructors met to finalize key details of the course and discussed their roles in the course including possible authorship of teaching cases aligned with their specialties. These instructor-planning meetings continued on most Friday mornings throughout the Fall 2013 semester and were held in a group study area in the enclave of a new Biological Sciences building on the LGU campus.

In the middle of the first day of class, students were recruited to participate in the study and thereafter the course was audio recorded and all student work was collected and part of the analysis for this and other research studies. The class sessions were audio recorded, including after class discussions between students and instructors and debriefing conversations with instructors. Murakami took field notes during the class sessions, when possible, and kept a field journal to keep track of key tensions or issues throughout the class meetings. Students and instructors also participated in narrative, semi-structured interviews facilitated by Murakami in the beginning and end of the semester. These documents and audio files were downloaded and compiled into NVivo10 for selective transcription and qualitative analysis coding first for sources of tension. After the first round of analysis, each of the teaching units had a collection of field data and associated tensions. These tensions were later categorized into four interrelated sociocultural tensions directly associated with sustainable agriculture education. We describe this system of tensions through two ethnographic vignettes with two of the teaching units (Maanen, 1988).

Historical Context of the Case:

The APSA course was created to be an advanced core course for sustainable agriculture majors and minors. The sustainable agriculture major and minor grew from the dedication of the LMW LGU advisory board for the Community Food Systems and Sustainable Agriculture Extension Program. The first courses were taught in 2006 and APSA was first taught as a pilot course in 2012. The course was meant to fill a gap at the LMW LGU by offering a course that exposed students to regionally relevant sustainable agriculture production practices. Drawing on Hendrickson's network of farmers, researchers, and experts in sustainable agriculture she determined the course focus on managing agroecosystem resources like energy, water, soil, biodiversity, and labor. These agroecosystem resources provided the basis for units in the pilot version of the course in Fall 2012. To support instruction in this course, Hendrickson solicited the help of some of the team of researchers and instructors from Table 1. After this 2012 pilot version of the course, the team was concerned that students were not able to adequately apply principles of sustainable agriculture and agroecology in authentic contexts from participating in the primarily lecture format of the course. With these concerns in mind, Murakami proposed a reorientation of this course to focus on local farm problems connected to global SSIs and encourage students to practice decision-making. He proposed documenting the sociocultural tensions encountered while enacting this new curriculum as part of his dissertation studies in Science Education.

Description of Course

We communicated the unique philosophy for the course and worked to develop a shared understanding of our approach with students during the first week of class, in one-

on-one interviews, and through course documents. The following course learning objectives were listed on the course syllabus:

- *Demonstrate an understanding of advanced principles of farming that sustainably manage soil, water, energy, financial, and human resources.*
- *Describe how crops and livestock can be integrated in productive working landscapes that help farmers achieve quality of life and economic viability while stewarding natural resources.*
- *Apply an agroecosystems approach to create short-term and long-term goals for sustainable farm operations.*
- *Identify opportunities to build relationships between consumers, distributors, and sustainable producers;*
- *Balance decisions about everyday issues in agricultural production by weighing economic, social and environmental objectives and outcomes using an ethical and sustainable framework.*
- *Evaluate farms and decisions using evidence-based agroecosystem analysis methods*

The instructors also shared that their orientation as situated learning theorists meant that we believed learning is not “merely memorizing a collection of facts or describing the relationships between concepts” and that we approached the course as trying to teach a way of thinking and a process of making decisions about agricultural resource management (Appendix A, Syllabus, p. 1). Further, we took the first class session to talk about *wicked problems* in sustainable food systems and emphasized the importance of diverse ways of knowing and thinking to address issues that are constantly changing, contextually dependent, and rarely have a *right* or *wrong* answer. Mark, one of the collaborating instructors, expressed concerns regarding this philosophy in the instructor planning meetings and the class sessions. During this first class session, he interrupted Helen and explained that we can often find a *best* answer to problems. Later, we elaborate on this epistemological and paradigmatic sociocultural tension that a number of community members encountered, but in general believe that this is an

example of the value and challenge of having multiple instructors in transdisciplinary collaborations.

The APSA course met Monday afternoons from 3:00 – 5:30 pm. The first half of the class was typically dedicated to wrapping up the previous teaching unit, and discussing the final reflection assignments that were due on Thursday evenings. The second half of class introduced a new issue, provided time for students to have large group or small group discussions to identify objectives, or key areas of focus, and choose a specific objective to individually work on. Students posted their assigned responses using the wiki tool on the course Blackboard site. These wikis were shared and discussed with the class during the first half of the next session. After each of the teaching units, students completed a reflection assignment requiring them to make a resource management decision in the given context, support with different forms of evidence, and consider tradeoffs in economics, the environment, and quality of life.

Table 4 provides a brief overview of the nine teaching units that were developed and implemented for the 2013 version of the course.

Table 4: Teaching units. Brief description of context, unit learning goals, and special notes.

Teaching Unit/(SSI)	Context	Learning Goals	Notes
Managing Bindweed/ (Glyphosate)	1/12 acre vegetables in Urban Agriculture	Help community group decide strategies to address Field Bindweed	Used for initial discussion and not completely pursued with student objectives or final reflections
Factors in Agroecosystem/(Soil degradation)	300 acre Row crop farm	Identify all the factors involved in making agricultural management decisions	
Selecting a Farm	Various options	Select a sample farm and describe what to look for in a farm operation	This was used to prepare students for their work on a farm plan assignment
Prairie Birthday Farm/(Soil Degradation)*	40 acre, Small, specialty crops	Improve and maintain soil health using without off- farm inputs	Recommendation letters were written to the farmer as a culminating task
CRP** to Row Cropping Systems/(Labor)	300 acre, row crop farm	Design a 5-year cropping system for transitioning from CRP to row crops	Students participated in optional field trip and wrote letters to farmer
Three-season Vegetable Rotation/(Labor)	1/12 acre, urban vegetable farm	Design a 3-season cropping system for vegetables and include possible cover crops and soil amendments	Provided optional field trips and virtual tours of nearby urban farm and
Water Quality and Quantity Needs and	150 acre, conventional cattle grazing, combined	Address an issue between Farmer A and Farmer B	Students assumed the role of an NRCS agent and offered

Rights/(Fresh water)	with neighbor's new orchard and chicken operation	based on compromised quality and quantity in a water scarce region	recommendations for management and negotiation with neighbor
Pastured Energy Farm/(Climate Change)	450 Acre, intensive cattle grazing	Justify the environmental benefit of converting from row cropping to grazing	Students created a budget, and explored tradeoffs between row cropping and grazing operations paying particular attention to greenhouse gas emissions
Conserving and Producing Energy on a CSA Farm/ (Fossil Energy)	100 Acre, diversified vegetable operation	Create a five year plan that identifies priorities for on-farm energy saving and energy generating projects	Students compared their priorities to what the farmers actually did over the 5-previous years.
Resilience, Risk, Diversity, and Resistance in Agriculture/(Chemical pesticides)*	Not bound to specific farm context but representative of Midwest region	Describe management strategies that could help limit risk, weed and pest resistance, and maximize resilience	This case was designed based off several student concerns and added to meet these needs

*Described in ethnographic vignettes

**Conservation Reserve Program

Findings:

In Figure 1 we describe four types of sociocultural tensions that emerged from our experiences designing and enacting this revised curriculum in APSA: (1) **Individual Tensions**, (2) **Community Tensions**, (3) **Local/Global Tensions**, and (4) **Local**

Tensions. This is not meant to be an all-inclusive typology for the sociocultural tensions we observed, nor can these different types of tensions be understood in isolation. We argue that these are a system of tensions that were associated with instructional decisions made by the teachers as they tried to construct a community of practice that supported learner identity formation but also was responsive to the global practice of sustainable agriculture and considerate of contextual factors associated with the culture of the LMW LGU.

Individual Tensions represent instances of attraction or repulsion from the learning community. We argue that this first type of tension is experienced between an individual and the community. In other words, these tensions manifest when learners might be asking themselves while making meaning of their experiences in the group, is this sustainable agriculture community *for me*? In the discussion section we talk about how this type of tension between individuals and the community has important implications in terms of *what* counts as valued knowledge and *who* counts as a practitioner of sustainable agriculture.

There were also **Community Tensions**. These tensions were most noteworthy amongst the instructors in the group as they negotiated their role as a member of this classroom, the type of learning experiences that were valued, and how to best evaluate and support learning. The way in which these tensions were resolved led to **Local/Global Tensions** between this local case community and the *global* community of practice. In short, these tensions were related to decisions that were made by instructors to meet the cultural and contextual needs of the participants in the course. In negotiating these tensions, the community might ask themselves, in what ways is this course representative

of the practice of sustainable agriculture in general, but designed to meet the needs of the particular local context.

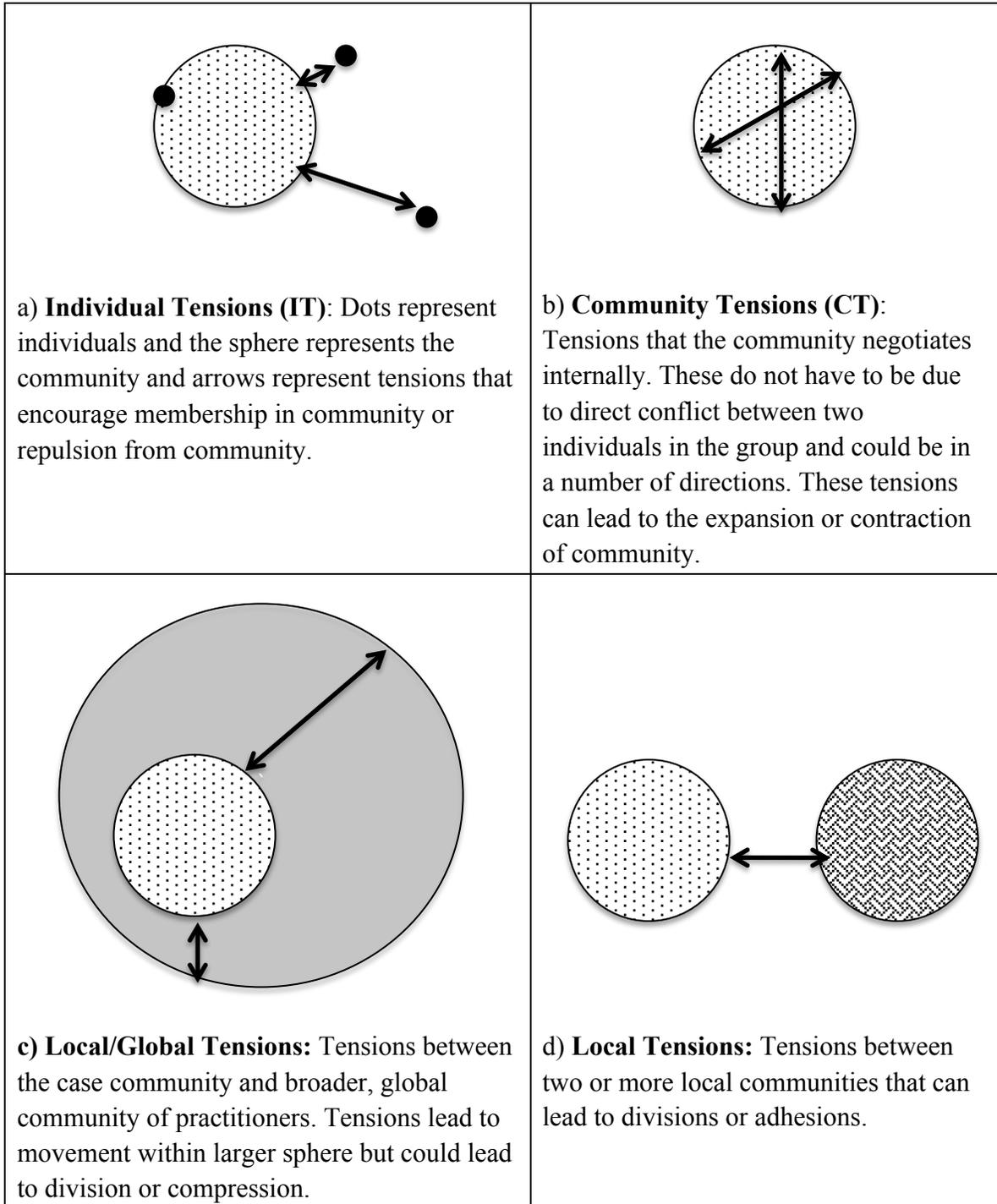


Figure 1: The four types of sociocultural tensions.

Finally, there are the **Local Tensions (LT)** that existed between the different local communities of practice in which our participants were members. For example, students brought to light differences between the APSA course and an Agriculture Marketing course, or Animal Science course at the LMW LGU. These tensions are important in terms of how our specific classroom community identifies and differentiates itself, for better or worse, from other communities. Resolving these inter community tensions is equivalent to understanding the differences between two different ways of thinking and in the process pragmatically making progress together. All of these types of identity tensions are important to keep in mind when designing and enacting sustainable agriculture education, especially if the aim is to move from the margins at LGUs.

Teaching Unit Vignettes

We situated these findings by presenting ethnographic vignettes that represent several of the actors in the case as they experienced these four sociocultural tensions while designing and enacting these teaching units. These vignettes focus primarily on how we created the units that spanned a variety of agricultural contexts and addressed key issues facing agriculture. We embed student and instructor voices as they reflect on their experiences. We included a designation of the specific tensions throughout these vignettes to help signal to the reader how we interpreted and justified these four interrelated sociocultural tensions.

Prairie Birthday Farms:

This teaching unit was created by Kyle, who knows Jennifer (the farmer) and Prairie Birthday Farms well because of the soil microbiology research he has been conducting there for over ten years. We chose this farm because it emphasized managing

a key resource, soil, and showcased Jennifer's passion for soil health, ecological diversity, and reducing off-farm inputs – all globally important and pervasive themes in sustainable agriculture. To design this unit, the instructors asked a set of questions that helped focus the unit on providing adequate nutrition to plants by limiting off-farm inputs. First, what is it that the farmer is most concerned about? Then, how does this problem relate to other local or global issues in sustainable agriculture? Finally, what could we expect the students to know and be able to do in this situation? Even though the farmer has already tried a number of innovative techniques, the farmer was most concerned about some recent Mg and Mo deficiencies in the soil. Kyle suggested that these micronutrients are becoming more and more important in soil analysis, especially in areas that had been “farmed out” (the situation for PBF). In sustainable agriculture, there is more to soil health than simply nitrogen, phosphorous, and potassium, which is typical in conventional soil analysis and management, and globally there is the issue of rising costs for fertilizers and regional fertilizer shortages. Therefore, exposing students to the ways in which these issues might be encountered by farmers and exploring management strategies that can reduce off-farm fertilizer needs became our priority.

As a whole class, we read through the teaching-case description (Appendix B) and asked the students to generate clarifying questions, most of which were geared towards Kyle because of his intimate knowledge of the farming context. In the background description presented to students to engage them in the issue, we shared that this farmer was already implementing a number of soil health management techniques such as planting native prairie grasses, applying charged bio-char, and making cold compost from the farm site. Interestingly, the clarifying questions asked by students

included topics related to the physical descriptions of the farm, vocabulary used (e.g. What is heirloom fruit?), and the philosophical decisions of the farmer. In all of the units, we asked the students to think about what we need to know to address the key issues that the farmer is experiencing (i.e. maintaining and improving soil health, addressing micronutrient deficiencies and limiting off-farm inputs). Students generated a variety of questions in class, and chose which topic from these questions they would research for the next week, and created a wiki-entry on the course Blackboard site. We asked students to address their guiding question for the objective, provide evidence from resources they found, and explain how it might be applied to the Prairie Birthday Farm scenario. One of the students, Heather, spent hours exploring the fertility benefits of insects in soil. In other words, she wanted to know whether or not attracting a variety of insects might be able to, over time, make contributions to soil health. After a number of web-based searches she essentially concluded that researchers do not know much about this topic. Heather later shared that she did not enjoy the experience at the time (Individual Tension), but she thought it was useful to have the experience of finding out something that scientists have not explored.

While enacting this teaching case, the instructors realized from the initial discussion with students that collectively our learning community did not have a solid grasp on what we meant by soil health. The students were assigned some additional readings and were working in small groups to develop working definitions of soil health in comparison to soil quality. While the students were working on this reading summary sharing activity, the four instructors in the group would have ideally been listening to the discussions, providing key insights, and helping facilitate discussion. However, the

instructors were all unsure of what role to play, and encouraging the instructors to facilitate these focused small group discussions was still a challenge. This new role for instructors in the course, listening to student ideas and supporting discussion without turning into teacher-centered lecture, was an ongoing individual tension for instructors (Individual Tension). This was the point in the semester when we realized that we needed to be more intentional about the roles and responsibilities of instructors in the course and led to negotiating this community tension (Community Tension). We discussed how this form of teaching and learning requires the instructors to assume different roles and associated identities as facilitators. This was, and continues to be, an ongoing challenge for instructors in the community of practice.

After looking at their reading summaries, students were able to identify key points that we were looking for as instructors. We decided to wrap up the case and prepared students to write a final reflection on PBF by encouraging the students to assume the role of an advisor to Jennifer. The students were charged with writing a letter to the farmer and presented several strategies that were contextually relevant (paying attention to scale, culture, etc.) and also shared the economic, environmental, and social tradeoffs of these decisions. These letters were eventually shared with the farmer and the students remarked that this approach towards assessment encouraged them to take the writing seriously. This work also helped students practice assuming the identity of a sustainable farmer by giving advice that they justified with evidence and crafted with respect to Jennifer's contextual and cultural expectations.

We found evidence, however, that there were sociocultural tensions held by a number of the learners in the community regarding views towards soil health and we

found that students did not seem to take away some of the most pressing SSI embedded in the unit (i.e. the widespread degradation of soil resources, scarce fertilizers, and the limitations of closed-loop approaches to agriculture). At the end of the semester, we asked students to evaluate and revise the units with partners working on each of the lessons. The biggest recommendation for revision for this unit from Glenda and Paula was to rewrite the description of the issue to include less information about what the farmer has already done. In other words, students felt like they were given the answers and were not compelled to dig deeper on these issues. However, we also observed local tensions and individual tensions between a group of sustainable agriculture majors who emphasized an interest in all of the unique practices that this farmer used, and conventional agriculture students who fixated on the idea that the farmer in the teaching case had an unrealistic view of soil health. “I don’t know, it’s like [the farmer] wants too much,” stated Lance when reflecting upon his experience in class (Individual Tension). It was evident that for a number of our students, primarily from larger agricultural backgrounds, it was challenging for them to see the value of offering advice to this farmer who is concerned with the micronutrient deficiencies that were observed in plant tissue and soil samples. “Do people even use these types of tests?” asked Carl in an end of the year interview. He continued, “I don’t think it is right that we’re spending time in class exploring methods that really aren’t even used on a large scale in agriculture [...] I mean, what percent of farms are using these tests?” Carl’s critique of some of these new soil tests that are used to better describe the degradation of soil from conventional crop management, seemed to be in conflict with his experiences on his family farm and his job with a regional agriculture services and supply company (Local Tension).

Here, we see an example of a network of tensions that precipitated because of the instructors' choice to feature issues of soil health and fertility management that are relevant to the regional and global practice of sustainable agriculture. In other words the instructors' choice to feature a farm issue that focused on soil and plant health using alternative soil analysis techniques positioned the classroom well within the global sustainable agriculture community of practice, but differentiated it from other local communities of practice that might view soil analysis through a different lens (e.g. NPK tests) (Local Tensions). This philosophy of reducing off-farm inputs is one way that a number of farmers are trying to work in the direction of sustainable agriculture, and so the instructors thought it was important to feature this concept into this unit on soil health (Local Global Tension). Earlier on, the instructors debated the relevance of PBF for the course because the farm is a relatively small producer and the economic viability of the operation was unclear. This Community Tension was resolved by focusing the case more on soil management strategies, but doing so created these Individual Tensions with a handful of the students, which possibly led some students to disassociate or de-identify with this farmer and her philosophy towards soil health management.

Resistance, Risk, Resilience, and Diversity in Agriculture

This was the final teaching unit in the APSA course and was designed to allow students to bring together concepts and principles that were brought up earlier in the semester through a lens of biodiversity. The aspect of this teaching case that is most noteworthy is the deliberation and negotiation that the instructors had before creating the teaching case (Community Tension). Initially, the idea was to integrate a contemporary issue in agriculture, glyphosate resistant pigweeds in the southern part of our state, and

encourage students to think about management strategies that could address this issue. However, defining the issue in this teaching case was problematic and contentious amongst the instructors in the learning community.

Coming from a background as a science educator, Murakami felt that it made sense to tie the issue of resistance back to principles in evolution, and design the learning experience for the students rooted in the phenomenon of forced selection that is the underlying principle that drives this resistance. This would lead students into viewing the role of biotechnology companies and also highlight the importance of planting refuges, but ultimately, encouraging the students to see that this resistance is just a side effect of a dependence upon monocultures that has drawbacks and puts the food system at risk. Further, he thought that there could be a companion case that included the issue of antibiotic resistance and its possible association with prophylactic antibiotic applications in swine and cattle feed lots.

Others took a more politically and culturally neutral approach that suggested that even if the issue is based in evolution, this focus might be unpopular with the students and the solutions from a management perspective are not as clear. In terms of managing for weeds and insects, they argued that resistance is more an issue of diversity. The problem of resistance, in their view, was more a result of the widespread application of glyphosate resistant strains of seeds and their repeated use in two crop rotations. By making management decisions that varied herbicides, pesticides, and crops, resistance might possibly be managed. This second position, was definitely less controversial and could open up the conversation to a number of different management practices that can be used to “prevent the plague” in agriculture, a problem that is not new to farmers. This

decision was heavily favored by most of the members of the group. Murakami admittedly would have preferred a more controversial tone in the teaching case implicating the rise of Glyphosate Resistance on a reliance on round-up ready corn and soybeans. It is possible however, that doing this would have marginalized a number of the students in the course who readily used or plan to use these biotech crops on their farms or in their future careers (individual tensions). This could have presented a scenario in which students associate anti-GMO sentiment with sustainable agriculture, which is not necessarily valid, and reduce their affinity towards identifying as a future or current practitioner of sustainable agriculture (individual tension). However, failing to outwardly problematize biotechnology and monocultures in modern industrial practices, or directly confronting issues with GM technology presents a local global tension as practitioners of sustainable agriculture. However, because of the identities of the students in the course and the context of the course in a LGU dominated by commodity interests the instructors opted for a more pragmatic way to position the teaching unit (local tension).

To support the concepts in the teaching case, Kyle provided a popular press article that referenced the growing concern regarding soil microbial health and the use of pesticides and herbicides. Students that identified with these agricultural practices were quickly challenging the credibility of the authors (from the UK), asking, “is this article even peer reviewed?” The conversation never became accusatory or flagrant, but some students were clearly defensive. The instructors in the course noted that chemicals are just one management tool, but it was easy to see that several of the students simply did not have any other management tools in their belts and were experiencing some individual tensions.

Eventually, this led the students into separate small groups that focused on ways to manage pests, weeds, and diseases. Later, they shared their wiki objective submissions with the whole group and students wrote a reflection journal about what could be done to prevent “the plague” and encourage resilience in agriculture.

One of the non-traditional students, Mike, who was actually a nurse but taking this course because of an interest in public health that he felt was rooted in a faulty food system dominated by corporate agriculture interests and government policies that supported the production of the wrong types of foods, expressed concern that the main point of the teaching case was missed by the instructors. The first author and the second author had in mind that resistance of pigweeds to glyphosate was just an example of the vulnerabilities inherent in our agriculture system because of a lack of diversity.

Resilience in agriculture (from the unit title) was meant to align with visions of farms modeled after nature that can withstand disturbances primarily because of diversity. Mike thought that when we were talking about **resistance** that we were hinting at the social movement associated with sustainable agriculture and agroecology in response to the accumulation of wealth and power in the hands of a few corporations that enhances the scale of **risk**. His decision to explore careers in alternative agriculture was an act of such resistance to the dominant forces in the food system. In brief, this learning opportunity and chance for critical reflection was missed in the classroom and is an example of a local global tension.

It is possible to assume that this was just because of a shortage of time or perhaps another example of trying to include too much information into the course. However, this decision was ultimately made in order to prevent heated arguments in the class. These

decisions and the associated tensions experienced along the way help identify the values and boundaries that help to unite, divide, and define membership in this classroom community of practice. This is especially true when students experience individual tensions, and might feel as if sustainable agriculture is not for them. As instructors, tending to the potential for individual tensions, might be problematic because it can result in positioning a salient issue in sustainable agriculture in a way that might not fully represent the root of the problems in issues of justice or social structures and create local global tensions. Within the community of learners, these instructional decisions are negotiated and help define the community relative to other local communities of practice.

Discussion

In this discussion session we focus on connecting the nature of the tensions faced in the course with relevant ideas in sustainable agriculture and science education. The orientation of the curriculum and pedagogical practices created a number of these tensions, but we believe that this pressure was important for transforming the community and practitioner identities in meaningful ways and at various scales. Galt et al. (2013) call for this type of transformative learning experience, and we present a snapshot of some of the challenges trying to embody new roles and formats for sustainable agriculture education. Bringing these and other tensions to light, give us the opportunity to critically reflect on the interaction of learner identities in this sustainable agriculture course community, which we suggest are associated with global tensions in agricultural sustainability.

One of the benefits of curricula using student-centered learning like SSI is that it builds learner ownership through assuming different roles and helps them practice

making complex decisions (Presley et al., 2013; Sadler, 2011; Sadler et al., 2007; D. L. Zeidler et al., 2005). The instructors in this case study had similar motivations and wanted students to experience the nature of issues and decisions encountered while practicing sustainable agriculture. Previous scholarship in science education suggests that there are specific orientations that teachers need to possess in order to feel comfortable employing SSI curriculum (Presley et al., 2013; Sadler, 2011). While planning, debriefing, and facilitating this course, the instructors expressed interest in resorting back to more conventional teaching strategies like lecture based teaching, and in other cases felt uncomfortable in their new roles as facilitators or area experts part of a teaching community (e.g. soil health discussion). Initially, they reported feeling like they were “jumping off a cliff,” and later they realized that the teaching cases were not equivalent to just “winging it,” rather a way to reorient the classroom to give ownership to the students. This tension that instructors felt lessened over the course of the semester.

The students also expressed some tensions related to whether or not this course structure was providing them with an opportunity to “take away hard facts.” During the first class session we suggested that in this course we did not think that there were “right or wrong answers.” In choosing these words, Hendrickson and Murakami wanted to emphasize the *wicked problems* in sustainable food systems and farm resource management and orient the class towards supporting a way of thinking rather than in pursuit of facts. Peter, an emeritus professor, raised his hand immediately, and contributed that as a scientist he thought it was problematic that we were saying there are no wrong answers. In an interview, he clarified that:

In the lab there are clearly observable facts and scientists work hard to understand the nature of those facts. I can concede to the sociologists that

there may not be one truth or that we are talking about approximations, and more importantly there are clearly wrong answers to a given dilemma

We suggest that this is an important epistemological tension that individuals had within the community that is representative of tensions within the world of sustainable agriculture and agroecology that can lead to individual and other tensions (Kloppenburg, 1991; Vandermeer & Perfecto, 2013). Reflecting on their own identities and ultimately their epistemological positions, it might have been disorienting for learners to make sense of this pluralist or relativist position. Over time, the community resigned that maybe in a given context there are clearly answers or decisions that would be an inappropriate allocation of resources, or perhaps a situation where a solution might be culturally and scientifically irrelevant to a given problem. For example, on Prairie Birthday Farms, recommending the use of anhydrous ammonia might be *wrong* because of the farmers clear opposition to this form of synthetic fertilizer and it also would not address the micronutrient fertility issues. However, it is more that we were hoping to engage students in realistic *wicked problems* that did not have simple answers. This issue was not discussed at depth in the course or in instructor planning meetings, and wrestling with this would likely help our classroom community of practice and other agroecology education practitioners become individually and collectively more epistemologically aware.

One of the students indicated a similar tension and recommended that the instructors offer the “top ten facts” to justify sustainable agricultural practices for the class. Murakami probed a bit further to better understand why she thought that type of learning outcome was valuable. Our course was designed to support decision-making skills, not necessarily provide a primer on the superiority of sustainable agriculture

practices over conventional methods. As discussed earlier, we are in favor of avoiding those direct comparisons in most circumstances. However, the student continued to explain that as a sustainable agriculture major (one of fifteen students majoring in sustainable agriculture in the college of agriculture) and taking courses with Agriculture and Agribusiness majors in classes that “touch on sustainable agriculture, but also kind of make fun of it,” it is understandable that this student and others like her might be looking for some quick fire responses to justify not only their major but possibly their career trajectory. This individual tension was a manifestation of the relative position of sustainable agriculture at our university with respect to other local communities of practice (e.g. agribusiness). Instructors in the course never provided those *factual* reasons to justify sustainable agriculture. We found these types of tensions that surround individuals deciding whether or not sustainable agriculture is *for* them an incredibly complex terrain that in this scenario engenders the need for clear answers to justify significant life decisions, but in our case the instructors exhibited some level of hesitance to make bold knowledge claims. Others in the field of sustainable agriculture (Berry, 1977) are not afraid of making these claims in writing or are from more alternatively minded university settings (S. Gliessman, 2013; Guthman, 2011; Holt-Gimenez & Altieri, 2013) that might be more welcoming to these more confrontational positions. Is it more productive, authentic, or responsible to make bold or alarmist claims as a sustainable agriculture educator to help recruit or retain students?

In our case study, we observed a number of students who were encountering this question of whether or not sustainable agriculture was *for* them and these types of identity tensions should be considered at a broader scale. One of the defining

characteristics of the practice of sustainable agriculture is an assumption that agricultural knowledge is situated in particular contexts and the preference of a re-allocation of power in the hands of smaller-land holders who might be better equipped to responsibly manage resources. However, it is hard to take this position without acknowledging the broader reality in the US and other nations of the increasing average age of farmers, decreasing number of farmers, and degradation of rural communities. To reverse that trend, it is important for the field as a whole to consider ways to encourage individuals to pursue future careers in sustainable agriculture. Research in science education focuses on recruiting and retaining members to Science, Technology, Engineering, and Math (STEM) disciplines and has highlighted the importance of tending to learner identities (Calabrese Barton & Tan, 2010; NSF, 2010; Tan & Calabrese Barton, 2010; Tan et al., 2013). Experiences in undergraduate level courses and the associated identity tensions are one possible factor that influences student career paths (Jackson & Seiler, 2013). It is important to note that the career path in sustainable agriculture is arduous because of political economic factors that have led to the consolidation of agriculture and significant barriers to accessing land, especially after accumulating student loan debt. We do not expect *all* of our students to be sustainable farmers, or farmers at all, but the course was designed to allow learners from a variety of backgrounds to solidify what it means to think like a practitioner of sustainable agriculture. We hope that more research is conducted to better understand how learner experiences in agroecology education can shape identities and that our study has brought this notion of identity formation (Tan & Calabrese Barton, 2007; Wenger, 1998) to the discipline.

One of the greatest opportunities to perpetuate sustainable practices is to encourage students from conventional farming backgrounds to practice assuming identities as sustainable practitioners. We noted several tensions that emerged when students thought about the extent to which they could identify with sustainable agriculture. Some of these students worked or planned to work on larger family farms and/or agriculture services companies. They expressed internal conflicts related to a number of the learning experiences in class, especially in relationship to the use of off-farm inputs like synthetic fertilizers, pesticides, and herbicides. In their other local communities of practice (work, family farms, weed science) using these inputs were important tools that helped support productivity and were necessary to generate profits. Carl said, “you know, I work for a chemical company, so they don’t like it too much when you start talking about reducing inputs.” Lance reasoned, “we sell fertilizer and GM seeds, so we want people to use them [...] but we’ve planted cover crops, I convinced my dad to plant a thousand acres of cover crops in some of our poorer soils”. The students here are experiencing an important conflict because in the course they are charged with assuming identities of farmers who are more interested in building soil health in addition to productivity and profitability, but students acknowledge that in all reality, outside of the classroom these approaches might not be acceptable. These tensions are important because they are not only evidence that students are considering transferring the practices covered in the cases in class to other community and regional contexts, but they highlight barriers that might change over time.

Tensions experienced between local communities can lead to possibly problematic polarizations that throughout the course the instructors sought to avoid. In

this particular context at a LMW LGU with a marginalized sustainable agriculture program, it was important for this community to be able to congenially co-exist with well-established agriculture business and agriculture economics programs. This context created tensions within the community that could lead to further tensions within the global community of sustainable agriculture practitioners but also indicates important opportunities. Other agroecologists might have started a teaching unit by problematizing monocultures for their lack of diversity that is not found in natural ecosystems. However, this presents a polarization for large-scale producers in the class and other commodity interests that can be avoided by instead focusing on an issue, weed resistance to roundup, and exploring a variety of tools to address the problem. Along the way, students still come to realize that monocultures or aspects of biotechnology are problematic, but they connect those dots for themselves. A number of curriculum decisions were made from this pragmatic position to find how sustainable agricultural practices offer important tools to address issues that conventional producers are concerned with while also avoiding palpable conflict within the college. Functionally, it is not favorable to create these boundaries (sustainable/not sustainable), because of the alienation and assumed elitism that has already plagued the field of agroecology. However, watering down, overusing, or coopting the terminology is similarly problematic. As the sustainable food movement gains momentum, there is some evidence that corporate agriculture interests and large landholders have already captured the language and rhetoric of sustainability. The early sustainable food system activists were initially working in opposition of these players; is it productive for agroecologists and sustainable agriculture educators to continually work directly against these entrenched, wide reaching actors in the food system?

Sustainable agriculture education curriculum designers make decisions that position themselves relative to a number of other communities of practice within the food system and this can generate numerous sociocultural tensions. It is challenging to imagine or understand all of these tensions, but we argue that it is detrimental to ignore them. We find it important to consider questions such as, how can we design agroecology learning environments to support sustainable agriculture identity formation for *all* students? How can we make sure these environments reflect and value local and global knowledges? How can we bring tools of sustainable agriculture away from the margins while maintaining legitimacy? Engaging in this design process is the perpetually fruitful and *wicked problem* that unites practitioners of sustainable agriculture education. We argue that this case study provides evidence that engaging in the revised curriculum that focuses on SSI embedded decision-making and leans on the local knowledge of farmers, students, and researchers is one way to encourage ownership and negotiate these identity tensions. However, this work is ongoing and requires consistent revisions and considerations to meet changing local needs and global advancements.

Conclusions

Our case study has helped highlight important tensions within the field of sustainable agriculture and agroecology that educators and curriculum designers must confront. First, should the term “sustainable” be used in a normative or conditional sense, or should it be used to emphasize the practice of making decisions in the direction of sustainability? In this study, we aimed for the latter but found it was easy to slip into using it judgmentally. This choice in language is not trivial and can lead to significant local tensions surrounding sustainable agriculture programs. Second, is it possible to find

a balance between valuing situational, regional, or local knowledge and global knowledge? We used local farm cases to emphasize the importance of making decisions in context but our students and instructors struggled when they were not given concrete answers. This epistemological tension is prevalent in the field of sustainable agriculture and agroecology as it tries to differentiate itself from the hegemonic agricultural sciences but maintain relevance in academic contexts (Kloppenburg, 1991). Third, to what extent should we take into consideration that sustainable agriculture educators must simultaneously support learning about sciences, practices, and social movements? This is an ongoing debate between the authors and curriculum designers under study, but we feel the structure of the course we describe supports all three. Students are viewed as joining a community of sustainable agriculture practitioners or joining the social movement that values scientific knowledge amongst other forms of knowledge to inform responsible management decisions. Our instructional decisions were influenced by a number of different factors as we tried to align ourselves with research in the field and our context in a LMW LGU. Our response to these local and global tensions in the field of sustainable agriculture position our local community and helps describe our group and individual identities.

Overall, we believe that empowering students, valuing their knowledge and insights, and providing space for them to practice assuming identities as participants in a sustainable food system is an important theoretical and philosophical orientation for our course and other agroecology classes. Doing so helps a learning community move towards an enactment of sustainable agriculture education that challenges instructors and students to assume new roles but also generates a variety of sociocultural tensions. The

instructors in the course demonstrated a level of vulnerability by conceding that they too are learners in the community, in terms of figuring out how to best engage, evaluate, and support students, but also in terms of addressing local agricultural issues and making tough trade-offs between the environment, economy, and quality of life. We hope this paper brings light to the sociocultural tensions that all learners face in a variety of learning communities. We believe this provides an opportunity to analyze differences in the underlying value systems of communities of researchers and practitioners engaged in the *wicked problems* of sustainable agriculture education.

CHAPTER 3: EXPLORING EQUITABLE SCIENCE ASSESSMENT PRACTICES AND FEMINST – STEM IDENTITIES

Introduction

Science education researchers are faced with important philosophical questions embedded in issues of individual and collective identities. As a global community of practice (Lave & Wenger, 1991; Wenger, 1998; Wenger et al., 2002), the way researchers and teachers answer these questions through their discourse and practice help shape the type of science educators we are *becoming* and the value, and *values* of, our collective work. In this paper, we bring attention to two such questions that are unpacked before exploring our research context in a college science course.

The first question is, what is the purpose of Science, Technology, Engineering, and Math (STEM) education? There has been an increased emphasis in STEM education from political messaging (NSF, 2010), federal funding, and corollary research (Carr, Bennett, & Strobel, 2012; Mahoney, 2010; Milgram, 2011; Tan et al., 2013). In some cases, the purpose of STEM education is clear – recruit and retain talent into careers that apply STEM knowledge and practices. Many agree there is good reason to be interested in preparing learners for STEM careers. There is anticipated growth in the number of STEM jobs available, STEM workers tend to earn more than other sectors of our economy, and STEM disciplines are likely sources of innovation that can lead to enhanced economic prosperity (Langdon et al., 2011). Conversations about investments and reforms to STEM education represent the US domestic policy responses to support competition in the global economy (NSF, 2010). This rhetoric leans on seminal work by Becker (1993) that helps justify investments in *Human Capital* through education and training to enhance future economic growth. While there are similar arguments in the

UK, EU and Asia, STEM rhetoric in the US evokes messages that go back to the 1957 launch of Sputnik in Russia. Our current political global economic context suggests that future economic growth for any nation is going to be dependent upon, in part, the aptitude and innovation of STEM citizens and workers. However, should preparation for those careers be the main purpose of STEM education or science education in general?

Critical Feminist Science Education (CFSE) researchers have developed language and tools in science education teaching and research that emphasize a reorientation of the purpose of STEM education reform to focus on addressing glaring injustices that women and non-dominant groups in STEM fields experience. This work has opened up spaces for empirical and pedagogical practices that help women and other underrepresented groups in STEM fields come to feel as if STEM is *for* them and introduces the complex problem of an *identity gap* (Tan et al., 2013; Calabrese Barton et al., 2013). Many researchers have also contributed important feminist perspectives on science education (Brickhouse, 2001; Kahle, 1985; Kleinman, 1998; Scantlebury, Kahle, & Martin, 2010) to better understand the complex trajectories for women pursuing STEM careers while elaborating stories of injustice beyond the statistical underrepresentation (Brickhouse & Potter, 2001; Tan & Calabrese Barton, 2007, 2010; Tan et al., 2013).

Despite enhanced rhetoric and functionalist educational philosophical perspectives embedded in STEM education reform, these critical feminist perspectives in science education offer powerful resistance to a narrowed purpose of simply career preparation. Zeidler (2014) offers provocative criticisms of the recent STEM movement in science education and pushes against a functionalist meta-narrative that disregards the importance of humanities and the arts to the realm of science education that serves

democratic educational philosophies and aligns with sociocultural views of learning. Is it possible for science education researchers to resist the power associated with STEM language and discourse that permeates our community of practice? While researchers and academics adhere to notions of STEM reform to align research to increased funding opportunities, we have noticed some of this work as collection of *improvisations* (Holland et al., 1998) within political and institutional structures to make progress towards equity, democratic science education, and a holistic realization of science education for *all*. These collective improvisations construct the identities of science education researchers and represent keen opportunities for agency and change in our field in service of broader values of social justice and sustainability.

In our research, we have also decided to participate in the STEM movement to help provide additional nuance and expand the purpose of STEM education beyond functionalist, career preparation. This is an act of resistance against the further neo-liberalization of science education and higher education in general that aims to apply market-driven and market-serving solutions to complex sociocultural problems (Giroux, 2002). We hope that this work opens up spaces for further self-awareness to the ways that politics shapes research in science education and also challenge the field to expand what counts as STEM to include what we call Feminist - STEM (F-STEM) disciplines, a concept that we later clarify.

The second philosophical dilemma we consider is related to the purposes of assessments in science education (Fusco & Barton, 2001). We are practicing in the era of high stakes standardized testing, and for many teachers and students, assessment is mistakenly viewed as merely a tool to differentiate students or provide accountability

(Pellegrino, 2012; Pellegrino et al., 2001). While the resistance against high stakes assessments is not new, there is growing emphasis in the area that we call Equitable Science Assessment Practices (ESAP). This work comes from a variety of methodological perspectives and focuses on meeting the needs of English Language Learners (Lee et al., 2012; Lyon et al., 2012; Siegel, 2007; Siegel et al., 2014; Siegel et al., 2008), taking into account cultural validity issues during assessment construction (Solano-Flores & Nelson-Barber, 2001; Wolf et al., 2008), enhancing teacher knowledge of assessments (Lee et al., 2008), and using assessments as a way to share authority around what counts as science achievement (Fusco, 2001; Fusco & Barton, 2001).

Some of this ESAP research has focused on classroom assessments (Siegel, 2007), formative assessments (Lyon et al., 2014), or alternative assessments (Fusco, 2001; Fusco & Barton, 2001; Lyon et al., 2012; Mamlok-Naaman et al., 2007) to support learning and enhance instructional decision making in formal and informal science learning environments. We do not believe that this research and practice in equitable assessment is *only* for English Language Learners or other marginalized groups and focus on expanding this research to encompass new orientations toward equity that extend beyond access. From this perspective, science assessments should *support* learning for *all* students, but doing so requires a complex system of knowledge and practices embedded in local knowledge of learners, diverse scientific disciplines, and unique sociocultural institutional contexts.

Much of this previous research in ESAP features sociocultural views of learning that requires special attention from the assessment design perspective. For example, we focus on the combined sociocultural lenses of communities of practice (Lave & Wenger,

1991; Wenger, 1998; Wenger et al., 2002) and identities and agency in cultural worlds (Holland et al., 1998) to describe learning. These theoretical views elevate the importance of identities-in-practice and the ways that individuals learn to assume identities in response to sociocultural and socio-historical forces, but it problematizes observing and interpreting this process of identity formation within a constructed learning environment. We describe the work that we have done in an upper level, transdisciplinary, college science course in agroecology as a way to share challenges and opportunities of enacting ESAP that aim to support science identity formation.

Previous research has shifted the purpose of science assessment to increase access for historically marginalized learners, but has also elevated the importance of science identity formation through meaningful participation in communities of practice (Lyon et al., 2014; Tan & Calabrese Barton, 2007; Tan et al., 2013). Some of this work emphasizes the acquisition of knowledge or embodiment of scientific practices within traditional science disciplines such as biology, physics or chemistry. Birmingham and Calabrese Barton (2014) describe a process for learners to take *educated action* in local environments to help learners make science relevant to their daily lives and support scientific identity formation (Mallya et al., 2012). Supporting learners' access to resources and developing culturally relevant assessments *of* and *for* science learning is an important starting point but should not be the end.

The purpose of this paper is to further apply this identities lens from CFSE to further clarify features of ESAP that can be enacted to support what we call Feminist – STEM identity formation in an agroecology course. We explore what counts in/as STEM education and position agroecology as a Feminist STEM (F-STEM) discipline. Next, we

synthesize literature in CFSE and ESAP to provide an initial framework for analysis. We hope to extend and establish a working understanding of ESAP through an analysis of our participants' voices, identities and experiences in an upper-level college science course. This exploratory study focuses on the following research questions: (1) How can women's identities in and outside of F-STEM courses be used to clarify features of ESAP? (2) What are assessment features that support the formation of F-STEM identities?

What counts as STEM Education?

One way to explore the implicit and explicit messaging regarding the purpose of STEM education and associated reforms is to consider what counts as STEM education. This provides the opportunity to understand who is set to benefit from the enhanced rhetoric regarding recruitment to STEM fields, but also who loses. Reform documents have indicated the elevated importance of an investment in STEM education to address a number of interconnected political and economic issues (NSF, 2010). First, it is a way to fill the gap that reportedly exists between the number of qualified graduates in the US to assume technical careers and the number of these higher paying jobs available, with more openings expected in the future (CRS, 2006). There is also widespread agreement that these STEM positions are less likely to be filled by women as well as underrepresented groups like Latinos and African Americans (NSF, 2013). This is one of the most palpable characteristics of injustice and inequity that is a reflection of deep cultural biases that must be addressed, though it is unclear how to best take action.

It is prudent to take into account that some of this rhetoric, initially raised by the business community, is also a tool for increasing the number of visas companies are

allocated to hire workers from India, China, Indonesia, etc. to fill these positions in technical manufacturing and computer science in the US (Atkinson & Mayo, 2010). In other words, we are not likely to fully experience the challenges of a STEM career gap because globally there is the workforce available. The STEM pipeline issue is in part a constructed political message that helps validate issuance of these work visas. Some might argue that it is problematic that foreign immigrants are filling positions that might be assumed by Americans – these STEM positions are typically higher paid, offer substantial benefits, and, if they exist in the future, might help to address some of the income disparity that are experienced locally and globally. In this way, politicians are able to leverage the interests of progressives hoping to make change towards social equity by increasing access to these middle-class jobs and the interests of bureaucratic and business elites hoping to receive a better-prepared work force without having to pay for it.

It is not the purpose of this paper to fully communicate the complex nature of issues related to the status of current and future STEM workforce, but our main point is that the prevalence of discussion related to STEM education is noteworthy because it is in tension with some of the more holistic or democratically focused visions of science education and science literacy (Zeidler, 2014). Science education philosophers have grown increasingly concerned that this movement within a global community of science education researchers towards STEM narrows the purposes of science education to focus on the preparation of new cogs for corporate machines.

Public science education would not exist if it were not in service of economic interests, but we hope that economic interests, democratic interests, and social justice

interests could work in balance to continue to push the field of science education. As mentioned earlier, much of the empirical work done in response to this STEM movement has focused on critical aspects of theory and practice to pragmatically make progress. For example, research on scientific identity formation, focusing on women and non-dominant groups has expanded the ways that researchers and teachers think about the design of learning environments and the myriad socio-historical barriers to assuming scientific identities in everyday life as well as in future careers. Work from CFSE uses issues of poverty and marginalization as starting points for advocacy and analysis, rather than variables to be later controlled through statistical analysis. This research tends to focus on informal learning spaces such as after school science programs and middle school learners (Calabrese Barton et al., 2013; Calabrese Barton & Tan, 2009; Calabrese Barton & Tan, 2010; Gonsalves, Rham, & Carvalho, 2013; Rahm, 2002; Tan & Calabrese Barton, 2007, 2010). We find this work particularly inspiring because it provides a model for sharing authority and accommodating diverse perspectives in terms of what counts as scientific knowledge (Calabrese Barton et al., 2003). Further, this work highlights the importance of leveraging the voices of some of the most marginalized students to help make sure teachers and researchers are authentically thinking about science education for *all* learners. This research has brought critical pedagogy (Freire, 1990) and democratic education to the center of feminist science education research. However, formal learning environments still pose significant challenges because of the institutional structures that shape learners experiences and reduce, constrict, and possibly stifle scientific identity formation. Here, we aim to bring many of the findings from CFSE researchers and their in-depth studies of science identities in practice or identity work (Calabrese Barton et al.,

2013; Tan et al., 2013) to a formal learning environment with learners near the end of the STEM pipeline.

There is an important tension deeply embedded within the culture and sociology of science that has led many learners to assume *identities of non-participation* (Wenger, 1998) with respect to science communities. The *figured world* (Holland et al., 1998) of science has a history of patriarchal hegemonic control over what counts as knowledge (Harding, 1991; Kleinman, 1998). It is no wonder that there are significant numbers of women and non-white males who feel as if the world of science is simply not suited for them. In fact, even after mastering content knowledge in science, there is still evidence that women increasingly de-identify with this discipline (Hill, Corbett, & St. Rose, 2011). In some ways, it might seem pragmatic to figure out how to encourage women and other non-dominant groups to learn to identify with the practices of science, however, it might be more transformative to consider changing the culture and norms of science to accommodate different ways of knowing (Harding, 1991). This is not a trivial tension, since the authority and power of science is well documented and meant to separate the subject of study (natural phenomenon) from the object of study (humans and tools). At the root of science, then, there is the separation between nature, humans, and everyday practice that is the source of its power through constructed objectivity, and also the source of authority and epistemological control (Calabrese Barton, 1998; Harding, 1991). This is especially true when scientific knowledge is applied in concert with technological advancements and engineering to create tools of civilizations and commerce that are produced en masse to support higher 'quality of life' for some, while also contributing to global environmental resource degradation and widespread human marginalization.

F-STEM Education

We argue that instead of changing people to learn to identify with STEM disciplines that might morally and ethically warrant separation, we should highlight existing science disciplines that aim to take into account responsible resource management, economic viability, local knowledge, and social justice as conditions for meaningful knowledge production to discussions about STEM. This position is admittedly more tenuous, but we argue that globally there is growing evidence that we are in need of exploring these types of feminist science careers, what we call F-STEM. Rather than finding ways to shuffle the learners who have historically been directly and indirectly marginalized by STEM disciplines into STEM career pipelines to serve the interest of elites, we argue that it is reasonable to bring Feminist STEM disciplines like Agroecology from the margins and consider the special challenges that learners face while learning to assume F-STEM identities.

Agroecology: An F-STEM Discipline?

Agroecology is often described as the study of, and participation in, sustainable food systems that aim to balance values of environmental responsibility, economic viability and social justice (Francis et al., 2003; Gliessman, 2007; Gliessman, 2013; Guzman & Woodgate, 2012). Wezel et al. (2009) synthesize the history of agroecology and argue that it is a science, practice, and social movement. In short, agroecology uses ecological and systems perspectives to understand and interpret farming and food systems to determine how to best move in the direction of food sovereignty, environmental justice, and social justice. Here, we use the term agroecology to include fields of study like alternative agriculture, sustainable agriculture, organic agriculture,

local agriculture, and civic agriculture. This emerging science and social movement has roots across continents, but values above all, local, situated, deep knowledge of farming and human ecosystems (Berry, 1977; Francis et al., 2003; Wezel et al., 2009).

Often, agroecology is positioned as an alternative to “industrial,” “conventional,” “high-input,” “technological,” agricultural sciences. While this type of dichotomy is sometimes culturally contentious, we elaborate on some distinctions of agroecology as they relate to our current context. First, this approach to managing agricultural resources is usually on the margins in the world of agricultural sciences, especially in the United States. Much of the emphasis in terms of federal funding and corporate agricultural STEM interests are on the side of large-scale production of commodities that rely upon heavy financial capital inputs to produce large volumes of cheap food while externalizing environmental and human costs (Patel, 2007). While agroecologists are not necessarily opposed to large agriculture systems, one of the critiques is that this approach to agriculture production is globally problematic because knowledge and tools developed in the US simply do not sufficiently transfer to diverse global contexts in ways that support sustainable development (Patel, 2007). In the US, farmers have the privilege of access to quality soils (especially in the Midwest region), favorable rainfall (though this is possibly changing), and access to credit to purchase equipment, seeds, and chemicals. In other global contexts, there are myriad limitations that prevent technologies from meeting the promises of its purveyors. In the process, globalization of the food system using advanced technologies and widespread exports might destabilize local markets for some farmers and regional foods systems.

Another principle of agroecology is attention to biocultural-diversity that helps make farming systems resilient to disturbances that are inherent in nature and agriculture. For example, industrial systems tend to emphasize crop rotations that reduce biodiversity, and require regular chemical fertilizer and pesticide inputs. With the development of round-up ready soybeans and corn, farmers might alternate between crops of legumes (soybeans) and grasses (corn) to take advantage of possible nitrogen fixation, but the continual application of a single herbicide (glyphosate) increases selection pressure for weeds that are able to survive. This is happening at an alarming rate, which is stimulating the development of new GM seeds that are resistant to new herbicides that might be more environmentally problematic than glyphosate.

Agroecologists are also generally interested in long-term, local and global food sovereignty, wherein farmers and citizens have control over the resources they need to access healthy, culturally relevant foods. Some argue that this focus on food sovereignty is fundamentally an issue of women's rights. Globally, women hold the knowledge and disproportionate burden of the labor of agricultural production and in-home food preparation (FAO, 2011). However, this work and knowledge is not accounted for in standard economic models or science disciplines (Kloppenborg, 1991). Moreover, women are globally less likely to have access to land, credit, or education that would help support and empower women to meet their families' needs (FAO, 2011). In the US, the number of women operators is increasing, but these operations are less likely to be economically productive (USDA, 2007, 2012, 2013, 2014). This is not attributed to a lack of their ability, rather a lack of access to resources or challenges negotiating male dominated spaces (FAO, 2011) .

Framework

Because of the importance of equity and social justice in agroecology and other F-STEM disciplines, we looked at emerging research in CFSE and ESAP to guide the development of our agroecology course and this present research. While it is not possible to review all of the literature from these two areas of scholarship, we aimed to synthesize common themes that can guide the design and enactment of ESAP and help clarify features of assessment practices that might later inform the construction of an empirically grounded framework. From scholarship in CFSE we borrow a critical and advocacy paradigm seeking meaningful change for our collaborators by elevating their identities, voices, experiences and stories (O'Neill & Calabrese Barton, 2005; Tan et al., 2013).

Additionally, this research in CFSE has highlighted the importance of encouraging learner ownership in science learning environments (Gonsalves et al., 2013; O'Neill & Calabrese Barton, 2005). One way to support this ownership is to learn how to leverage students' *funds of knowledge* that they bring from home or out of school settings to the science classroom (Calabrese Barton & Tan, 2009). Implicit in this position is a reorientation of the science classroom away from a banking method, wherein instructors hold all of the ownership, authority, and expertise that they are to dispense into the empty accounts in the minds of learners (Freire, 1990). Research in CFSE has brought attention to the importance of learner identities to better understand why women tend to lose interest in STEM despite academic success. Tan et al. (2013) explain that, "part of the reason for this disconnect is that while decades have been spent addressing the academic achievement gap between girls and boys, very little time has been spent addressing the science identity gap" (Tan et al., 2013, p. 1144). Using the voices of historically

marginalized STEM learners, CFSE has helped problematize the fact that many learners feel as if science is not *for* them as a career or as a relevant set of practices for everyday decisions (Brickhouse, 2001; Brickhouse & Potter, 2001; Gonsalves et al., 2013; Mallya et al., 2012).

Identity formation is not only a product of meaningful participation in a community of practice (Wenger, 1998), but also influenced by external sociocultural and sociohistorical factors that constrict possible identities, which learners might assume (Holland et al., 1998; Tan et al., 2013). One of the pedagogical challenges, then, is for science teachers to design and support learning environments that help learners enact a number of different identities associated with science as students come to understand their position relative to the figured world of sciences. We hope to extend this research that has been conducted during the middle school years to focus on undergraduate learners.

ESAP has yet to be fully defined, but has tended to focus on a set of practices science teachers and students enact in formal classroom settings to support student learning *for all*. To meet the growing needs of English Language Learners, these ESAP have been designed *for* learning rather than merely measurements *of* learning (Black, Harrison, Lee, Marshall, & William, 2004; Lyon et al., 2014; Siegel, 2007; Siegel et al., 2014; Siegel et al., 2008). ESAP include classroom assessments that can be formative or summative to provide valuable data that allows instructors to take informed action to meet the diverse needs of learners. In a comparative ethnography, Carlone, Haun-Frank, and Webb (2011), studied the ways that classroom structures and group assessment practices can influence the construction of science identities. They suggest that:

An analytic focus on identity allows consideration of a wide range of affective and dispositional outcomes such as the ways students view themselves in relation to science, the value they place on learning science, and their interest, commitment, persistence, and/or motivation to pursue science learning (Carlone et al., 2011, p. 464)

This work and others (Cobb, Gresalfi, & Hodge, 2009) has helped bridge the gap between in-depth and complex empirical work of uncovering learners' identities and its association with classroom assessment practices.

We hope to move ESAP beyond conceptions of *good* science assessment practices by including a foundational position towards equity and justice for learners and society in general. That is to say, it is not enough to support learners as they come to understand the science content or enact science practices, but the purpose of science assessment should also support the ability of learners to make meaning of scientific knowledge and practices through their *educated actions* (Birmingham & Calabrese Barton, 2014) to support visions of equity and scientific identity formation that extend beyond careers or the classroom. We believe ESAP should also help support engaged and informed action for the instructors and their students, empowering teachers and researchers to assume identities of practitioners of science education in pursuit of social justice. One critical component to ESAP is therefore specific attention to the ways in which assessment practices might support F-STEM identity formation. While we do not necessarily believe that all learners will assume F-STEM careers, all learners should be empowered to use the practices of feminist science to inform the myriad decisions they make and see the strengths and limitations of scientific ways of knowing to address complex issues in pursuit of equity and social justice. This present research is our first attempt to better understand the features of assessment practices that support F-STEM identities by learning from the voices and experiences of the actors in our case and in

conjunction with the existing literature that emphasizes feminist perspectives in science education research.

Data Collection

Glenda, Paula and Margaret are a subset of the women collaborators from a broader study of ESAP practices in a college science course. We focused on these women because they were members of the course on agroecology, Advanced Practices of Sustainable Agriculture (APSA), at a Large, Midwestern Land Grant University (LMW LGU). All of these women also indicated that they are interested in pursuing a career in some capacity related to this F-STEM discipline. Margaret, Paula, and Glenda grew up in suburban, urban, and rural regions respectively. Both Paula and Glenda were senior-level students majoring in sustainable agriculture, and Margaret as a senior minoring in sustainable agriculture. Paula identifies as Latina (Mexican American), while the others identify as White females. All three come from working class backgrounds and Paula and Glenda shared stories of experiencing some level of situational poverty and possibly food insecurity. For all three women, data was collected during their last full-time semester in fulfillment of their undergraduate degrees. Later, we build case profiles to feature noteworthy aspects of the learners embodied identities in and outside of the college agroecology course as they relate to our first research question.

The course is an advanced core-course that is a requirement for students majoring in sustainable agriculture. There were four co-instructors for the course with expertise in soil microbiology/weed science (white male), animal science (white male), agronomy (white male), and rural sociology (white female). In collaboration with the third author (expert in rural sociology) and the first author (background in science education) the

course was designed over a period of several years and first implemented during the fall of 2013 when this study took place. This transdisciplinary course was facilitated using a *communities of practice* (Wenger, 1998) approach that engaged learners in decision-making cases that were anchored in regional farm problems. The curricular approach was designed to accommodate the diverse expertise of the participants as well as the interests of the thirteen students enrolled in the course. During the semester, nine decision-making cases were developed, some of which featured socioscientific issues (Presley et al., 2013). Additionally, the course included two field trips to three different farm operations and invited local farmers as guest lecturers. We describe some of the process and sociocultural tensions experienced developing this course in a separate manuscript (Chapter 2).

A variety of formal and informal classroom assessments were developed or adapted for use in this course and were one of the sources of data for this study. The decision-making cases were introduced and discussed in small and/or whole group settings and provided students an opportunity to ask clarifying questions about the scenario. In some cases, the farmers who were experiencing these issues under study presented the problem scenarios and were available for questioning. Next, students would determine what additional questions needed to be answered or research needed to be done to inform the decisions made in each teaching case, and independently or in small groups became experts in these areas, wrote up reflections on an online wiki format using the tools on Blackboard, and later shared their findings with the class and explained the relevance to the problem at hand. Finally, students completed weekly reflection journals wherein they would make some of the agroecological management decisions, justify their

decisions with evidence, and consider tradeoffs in economics, the environment, or quality of life. At the end of the semester, students worked in small groups to evaluate one of the decision-making cases, provided feedback on what should be changed, and presented their criticisms to the class. All of this student work for our three participants was included in our analysis.

One of the first assignments for the course asked students to describe key experiences related to agriculture and the food system, describe future careers that students hoped to pursue, and also identify some key areas of concern related to agriculture. This was used as an assessment tool to help instructors know more about the *funds of knowledge* that learners brought to the classroom, as well as key areas of interest that could be used to design learning experiences later in the course. From a research perspective, we used this data and the initial interviews to get a sense of who our participants were in relationship to their F-STEM aspirations as well as how they viewed themselves as learners. For example, we also asked how they thought they learned best, and provided opportunities to discuss the challenges/successes experienced in the course in formal (round 1 interviews) and informal contexts (before and after classes). This provided valuable information to adjust instruction as well as later interpret the ways in which features of the course and instructional decisions supported/hindered identity formation.

The two narrative interviews in the beginning and end of the semester were audio-recorded and transcribed. All course work and course artifacts were collected throughout the semester and class sessions were audio-recorded. Additionally, the instructor of record for the course (the third author) participated in ongoing reflective interviews in

preparation for, and in response to, experiences in the class. The women were first recruited as participants in the first author's dissertation project and our analysis is based on data gathered during an initial 15-week period during the Fall semester of 2013, August - December, and later we confirmed analysis through member checking and follow-up discussions (Cho & Trent, 2006) during the Fall of 2014 and Spring of 2015.

Roles and Identities of the Researchers

The first author and the third author encountered this data as curriculum designers, course instructors, and researchers. The first author identifies as a bi-racial male (Asian/White) and led the research process as part of his dissertation study on interdisciplinary curriculum and assessment development in agroecology. The second author provided an external perspective and research and teaching expertise in equitable assessment, instructional decision-making, and college science teaching. The third author is a rural sociologist and the instructor of record of the course. She studies local food systems, sustainable agriculture, and consolidation/monopolies within the food system.

Data Analysis:

We used iterative qualitative research methods to help answer our two research questions (Coffey & Atkinson, 1996). To answer our first question on the ways that the stories and identities of the women in and outside of the agroecology course helped clarify features of ESAP, we organized and analyzed data collected throughout the fifteen-week semester using preliminary codes that were informed by the literature and the focus of our assessments. Like Tan et al. (2013) we were interested in the participants narrated and embodied STEM identities and focused on our three participants narrated views towards education, agriculture, learning, and assessment gathered primarily from

the initial narrative interview, the first week reflection journal, and the first part of their farm plan assignment.

Next, we coded our collaborators responses to regular reflection journals, their participation in the course wiki objectives and reflections about their experiences in the course from the beginning and end of the semester. While viewing these data we were searching for ways to elevate our participants' voices and be able to learn from their experiences and unique identities and interests in an F-STEM career trajectory in agroecology. One of our participants, Glenda, regularly searched for alternative ways to express herself — including poetry, and poetic language. This inspired our interest in poetic feminist research methodologies that offered unique, concise, and powerful ways to represent qualitative findings and uncover the identities of our participants (Hanley & View, 2014; Pendergast, 2006; Ward, 2011). With this lens of poetic analysis in mind, we re-analyzed data looking for selections of text that represented the essence of our collaborators' identities (Ward, 2011) while also featuring evidence of identities assumed within the course and in response to the assessment practices. We constructed *found poems* that include representative quotations from participants that were arranged into stanzas (Glesne, 1997; Hodyk, Soltane, & Hanley, 2014; Ward, 2011). We took a few liberties removing extraneous words, phrases, or utterances, but attempted to enter line breaks and unique language of our participants to feature their cadence, tone, and voice (Ward, 2011).

Evidence from our three participants' identities, experiences, and stories helped point to features of assessment practices that are involved in the complex terrain of F-STEM identity formation. We answered our second research question by analyzing the

variety of assessment practices enacted throughout the fifteen-week semester, paying particular attention to the structure of the class and assessment. We were initially coding aspects of assessments and student work that featured local knowledge, multiple perspectives/ways of knowing, student ownership, informed decision-making, balancing trade-offs, valuing student voices/interests, and authentic tool usage. Later, we went back to our three participants to think about some of the challenges and affordances that they narrated regarding our assessment practices, which led to our identification of four interrelated features of ESAP that are possibly involved in F-STEM identity formation. These themes were shared with our participants to seek confirmation and provide an opportunity for elaboration. We first introduce the themes through the found poems in our participant profiles in the findings section and later the themes discussed with respect to implications for teaching and future research.

Findings

Our exploration into how our three participants' identities in and outside of an agroecology course could be used to clarify features of ESAP that support the formation of identities yielded four themes that we represent in Figure 2. Our four themes: (1) allowing flexibility, (2) laminating voices, (3) sharing authority, and (4) scaffolding social justice, are meant to be conceived as interconnected features of ESAP that were uncovered through analysis of our collaborators experiences. These themes were informed by the stories and voices of our participants and were reflected in interviews, class assignments, and experiences participating in Advanced Practices of Sustainable Agriculture. In searching for ways to authentically represent our participants, we

developed found poems that we use to introduce our participants and ground our conversation of our four themes in their experiences engaging in F-STEM learning.

In our findings section we present each of our three participants (Glenda, Margaret, and Paula) by first sharing a representation of their identities in and outside of the agroecology course. We recommend reading these poems first, before reading the narrative description of the actors that reference aspects of the poetic representation and further contextualizes the voices and identities of our participants within the class and in relationship to features of assessment practices enacted that support F-STEM identities. In this way, readers can participate in the “decontextualization” and “recontextualization” of our participants’ stories to hopefully gain a glimpse of their essences and also learn from their narrated experiences and artifacts from the course (Coffey & Atkinson, 1996, p. 30). We have bolded the first lines of different stanzas in these found poems to help differentiate topics or content within the narratives.

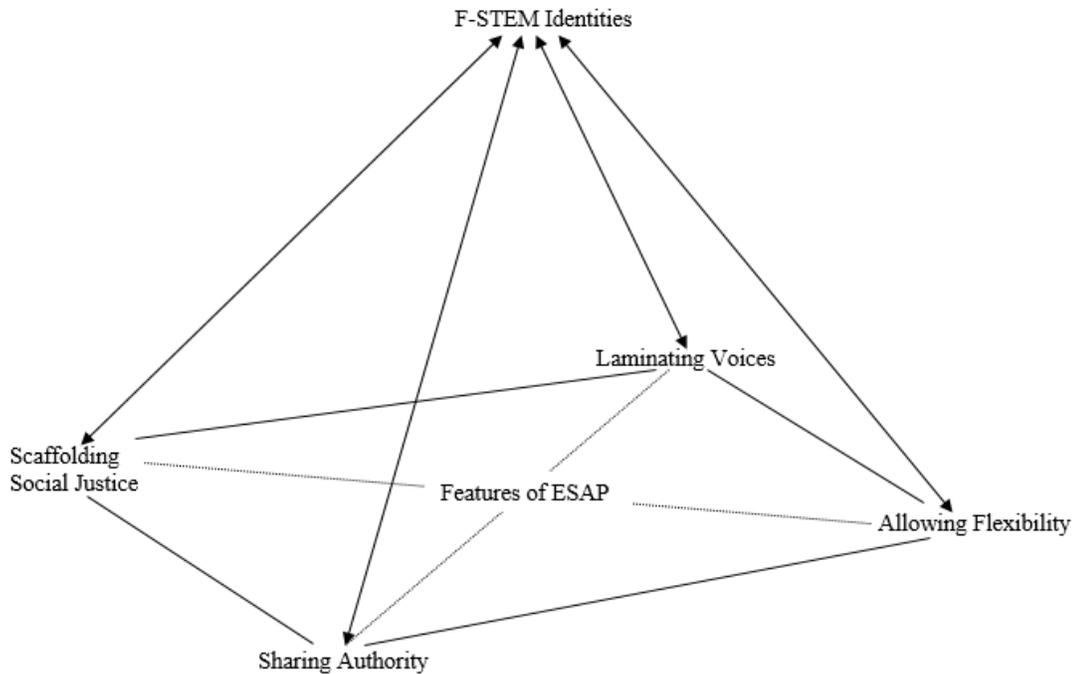


Figure 2: Features of ESAP that support F-STEM identities

The Flow Deep in my Core - Glenda

I've been to 5 different colleges.

I've always been a little bit of a rebel when it comes to education.

I never finished my high school diploma.

Plato, humanities, certain things don't change after 35 years.

(Interview 2)

For mother earth

and its inhabitant's sake

It is worth more to leave her be.

Truly.

People are a part of the natural world not separate from it.

(Week 2 RJ)

I am fine working with others and alone.

Sometimes working with an "other"

can make one wish they could work alone.

(Farm Plan)

There's a lot of hungry people.

There's no real jobs.

That's very,

Very sad to me.

(Interview 1)

Short-term goals:

Finish house foundation

Install woodstove

Continue to reclaim pasture area with moving electric fence and the 4 legged beasts.

(Farm Plan)

My experience has proven

the more diversity in a pasture the healthier the animals.

(Wiki Case 4)

I could go on about all the things

we talked about in class and regurgitate about species diversity, soil tests, water percolation and quality, reducing chemical inputs, health and pounds of beef raised, how we choose to spend our efforts and quality of life and, the almighty dollar
But instead

Earth

Teach Me

(Week 13 RJ)

They've heard enough college professors.

They want to listen to the old man Joe.

They want to hear what he has to say.

That guy,

old man Joe,

He's listening to his inner monkey

(Interview 2)

I feel angst

as I try to sort out my thoughts for this reflection.

Maybe because a "rubric" of points a measuring stick of sorts attached to reflection

baffles the flow deep in my core.

(Week 2 RJ)

With time

I hope that I will become

more a part of this local community and be able to bring animals

into nursing homes and schools

(Farm Plan)

If you ever need any silly old nut

you know,

that you want to bring into the classroom

you let me know

I'll visit.

(Interview 2)

Figure 3: Glenda found poem

Glenda – Allowing Flexibility

After leaving several other universities, Glenda ultimately pursued, and recently completed, her degree in sustainable agriculture at LMW LGU. She explained that her motivations for leaving these colleges were in part rooted in harsh feedback that she received from college professors regarding her views towards alternative agriculture 35 years ago. The first stanza in her poem (Figure 2) refers to the challenges she had returning back to college and losing credits she had earned, and her narrated identity as a “rebel” student. Glenda’s discourse informed by decades of applied experiences in managing herds, goat breeding, and serving informally as the “911 goat hotline” in the region during kidding season combined with her understanding of the complex political and economic factors that influence agriculture, inspired many of the students (e.g. Paula). These identities also shaped the course community.

Glenda regularly initiated critical discussions on topics ranging from glyphosate (the active ingredient in the herbicide roundup) in precipitation, critical deconstruction of the green revolution, and the problems she saw related to the corporate control of our food system. On the first day of class, Glenda started a tirade about “round-up rain” when the class was deciding whether or not it was appropriate to use the herbicide to control a particularly harmful weed in a small vegetable operation. Glenda regularly positioned herself on the left side of the large rectangular table in the class, while the traditional agriculture students sat firmly on the right, possibly the type of “others” that Glenda mentions in the excerpt from her farm plan assignment. The tension between Glenda and more conventional agriculture students manifested in regular eye-rolls, but for Glenda, she viewed the class as overall congenial. “I didn’t get cussed out or anything, so yeah, it was pretty good,” she said in response to a question about how the class negotiated

conflicts. She later shared that she had experienced a number of serious confrontations in other courses.

We included a number of different sections to this poetic representation to help capture the layered identities that Glenda and other students brought to the class. It was challenging to limit the representative quotations to build these stanzas because the stories that she narrated and her vision and passion for sustainability and justice combined with pragmatism, creativity, and agency made her an ideal student for F-STEM even though she considers herself a “rebel.” However, we could see how Glenda might run into significant troubles in a “traditional” science course because of the agency and liberties that she took in terms of alternative representations of knowledge and in some cases technical challenges with computer-based assignment submission or overly structured assessment tasks. .

Glenda helped elevate the importance of **allowing flexibility** in assessment practices to support identity formation. Glenda’s week 13 reflection journal featured a series of poems that she references to support her overall argument that transitioning from a row-crop operation to a pasture-based beef operation would be more sustainable (Teaching Case 7). The entry at the top of the right hand column was the preface to one of these poems. Ultimately, Glenda’s use of poetry and spiritual ways of knowing also gave *us* courage to represent our findings using poetic representation in this manuscript. For that particular week, her response was likely a product of an overly ambitious assignment that required students to consider the tradeoffs in economics, the environment, and quality of life that might come along with moving from farming a commodity crop like corn or soybeans using conventional methods to a grazing system

that took advantage of reduced fertilizer, machinery, and pesticide inputs. For Glenda, who was born into the world of agriculture and raised purebred small ruminants, the decision to enact a grazing system for the assignment was likely trivial and she found more meaning in presenting poems that cut through western sciences and a cultural obsession with the “almighty dollar”.

She also wrote about the “angst” she felt when presented with a rubric, freely stating in her assignment submission that it was stifling her innate energies or “flow” in her “core.” The rubric was initially designed to provide transparency and support for learners but she had the agency to make it clear that it was not supporting her learning. These types of reflections from Glenda and other students encouraged the course instructors to be flexible in terms of the ways that students represented their knowledge, for example, accommodating reasoning that include spiritual understandings of nature.

The concept of allowing flexibility also includes the overall structure of the course that was designed to provide options for students to navigate the class based on their individual needs or interests and also take advantage of the funds of knowledge students bring to the course. For example, for the Farm Planning assignment, Glenda was able to base her assignment on a small homestead where she needed to “reclaim pasture” on 6 acres. This provided a legitimate and relevant context for planning her dream farm and future role in the food and agriculture system. Other students were able to think of urban farms or large-scale operations, depending on their interests. In other cases, students noticed the value of being able to choose which aspects of the decision-making cases that they would research before reporting back to the whole class. This built-in flexibility in the design of our course allowed students to pursue interests or areas of

expertise. For the Case 4 Wiki assignment, Glenda focused on native species that can be integrated into pastures and spaces between apple trees as a way to improve nutrition for the animals and also bring up micronutrients from the subsoil – an area that resonated with her identities and experiences. In Glenda’s narration about “Old man Joe” we see that she values the deep, local knowledge that is prioritized in agroecology, and argue that she is perhaps talking about herself in this selection. Finally, her humble visions of using animals as a form of therapy for aging adults and children emphasizes her compassion and vision for a better world in conjunction with a long list of informed actions and the responsible practice and application of science.

Margaret – Laminating Voices

Allowing flexibility in ESAP provides opportunities for students to come to identify and engage with different practices and perspectives while self-regulating internal vulnerabilities as they encounter and perform new voices. We believe that assessment practices should provide opportunities to laminate voices. Here we borrow the metaphor of laminating from Holland and Leander (2004) who explain that “as laminates of the social affixed to personal experience thicken, they themselves become objects that mediate further action” (p.134). Holland and Leander work with this idea of laminating to explain how different interactions in the social world and experiences can become layered and bonded over time, that “allows for the continuing heterogeneity of materials” (p.134). In our case, we focus on the ways that learners are given opportunity to experience the power of different voices experienced in science course work and practice using these voices in the performance of a variety of roles and assessments.

That's the secret! – Just add water! - Margaret

I didn't like food science classes.

You didn't really learn anything about the social side of food. We had a speaker come in from Save a Lot Foods just an optional thing. But she was talking about how industry scientists are like 'How can you add more water to food to make it cheaper?' She was like 'That's the secret! Just add water! Water's free.' So you're basically giving people a food product with more water and less nutrition and trying to sell it for the same amount but a higher profit margin. That's where the concern is the profit margin. No one questioned it. From Save a Lot! For people who are underprivileged already! And you're putting water into their food? Most people aren't concerned with agriculture or the environment or sustainability. It's more like I don't want to just say make money but that's kind of what it is. Go to the industry and then make the food companies money. I don't know. I need to feel like it is important or have some purpose. (Interview 1, Interview 2, and Follow-up interview)

Groundwater in this area

is of already poor quality due to calcium and sodium carbonates chlorides and sulfates from the underlying geography of the area. Quantity is also an issue. Even in times of normal precipitation limited quantities can be drawn out of buried glacial channels. (Week 9 RJ)

The overlying management practice

is to use multiple sources of control. With diversified management practices as well as diversified crops. Risk will be averted resilience will build. (Week 14 RJ)

Yeah, I'm not sure exactly.

Like, the USDA thing I could see as being later in life. Like if I was a food scientist like I stayed on the science track and learned about the research and then make policies based on that like public policies. I've talked to Helen about whether or not people get their knowledge from the scientists. Like do they have the power to tell other people what should be done? That's kind of how I saw myself if I were to work in the food industry. I've also gotten interested in soil science so I just kind of have to figure it out. (laughs) (Interview 1)

Figure 4: Margaret found poem

Margaret is one of the only learners in our course (and in this study) that comes from what would normally be considered a STEM discipline, food science. However, her experiences and engagement with that field and the possible career paths seemed to be in tension with a fundamental concern she has for using her knowledge and voices in pursuit of something that allows her to feel that she has “some purpose.” Her first poem captures a significant episode for Margaret as she ultimately decided against a career path in the food science industry, and left the STEM pipeline. She described in class and during interviews how adding the sustainable agriculture minor allowed her to focus on the “social side” of agriculture and the food system, when food science was mostly “just science”. Her strong written analytical skills that she attributes to her required training in the natural sciences allowed her to earn high marks in the course, but she tended to be quiet during whole group class discussions, in part feeling she lacked the farming experiences or understanding of large scale agriculture that some of the other students brought to the classroom. When confirming themes for this study, we initially used the concept of “building voices,” to which Margaret affirmed as important but elaborated that from being exposed to some of the diverse perspectives in the course, she was able to see the world through her classmates’ perspectives and layer those voices with her own. This led to searching for something to represent this thickening and expansion that comes from engaging with differing perspectives and encountering new roles within a community of practice.

We included two selections from her reflection journals that emphasized her mastery of the language of science concepts embedded in the course assessments and also feature some of her growing interest in soil sciences. In the reflection about ground water,

students were challenged to understand a controversy that two farmers in the northern part of our state experienced regarding water quality and quantity from underground reserves. Margaret elected to investigate the ways that geological and geographical features played a role in the water issues. This exercise allowed Margaret to use her knowledge of soil science and soil classification to fuse new connections with hydrology and understand the way that it affects human systems. She represented her findings on the wiki in a poignant, well-organized tone and later explained to her class that the challenges that farmers were facing were a product of regional limitations.

The third selection was from one of the last course assignments, wherein students were asked to describe ways to minimize risks in agricultural production of commodity crops. We see her response as first evidence that she was able to achieve the learning goal, but more importantly leverage the voice of an agroecologist to help justify the system of management decisions she proposed. Despite growing up in a suburban neighborhood and lacking experience in agricultural production, these artifacts of expertise helped her accommodate a number of voices. In the closing stanza, Margaret is discussing some of her possible trajectories beyond the classroom. While we could not include them all in the representations, Margaret described a variety of career paths that she *could* pursue. Her recognized academic achievement in Food Science classes qualified her for jobs in industry and possibly a future in policy. She also applied to a horticulture program, did internships on a vegetable farm, before eventually pursuing a graduate degree in soil science focusing on soil health. We argue that these laminated voices and identities Margaret drew from helped provide this variety of options that *all* students should have when deciding careers.

This isn't for anyone else *but me* - Paula

After I graduated from high school

I just got a job at a bank.
The bank wasn't doing anything meaningful.
Food was one of the things that I enjoyed especially at the bank.
Everyone shared food in the break room.
It was like the only time where we could be ourselves
and not have to like sell credit cards
or set up loan applications and put people in debt.
The sub-prime mortgage crisis happened.
I got laid off.
I think it's important to not feel embarrassed of where you work.
I think my interest in agriculture has to do with fulfillment.
I didn't want to focus on business.
I'm going to take that knowledge
I'm going to go learn about science
and go learn about agriculture.
(Interview 1)

There's such a mixture in the quality

of teachers or professors.
Some are just like really engaged
then there are those who just like go through the motions
and present PowerPoints and talk.
I'm paying a thousand dollars for this.
I'm not learning anything.
Like why am I here?
I'm here because it's a requirement
and I need those three units.
It almost seems like an endurance exercise.
How engaged are they?
How vested are they in student learning?
It's yeah, it's just a mixture.
(Interview 1)

I like to plan and usually do so with the worst-case scenario in mind because I care about maintaining a comfortable life for myself and my family (Farm Plan)

I grew up in a household

we just had kind of a different situation.
My mom would work swing shift.
She would prepare food before she left for work.
Us kids, we would just eat.
The things she would cook were pretty basic.
Mexican food, and it was just staple foods, like, beans, like, rice
She went to Costco so much.
I can't have Pizza Pockets anymore because I've had too many
or Instant Lunch.
Like she would just buy things that were simple to prepare, and she didn't make much money.
When I had a son, I was like 22
it was important for me to feed him good food.
You can't just like bring a kid up on Instant Lunch.
(Interview 1)

I was doing my farm plan

and I was like, why do I have to do this?
It felt like a drag.
Then I walked away
and then I was like
OK, there is a point to this.
It's so that *I* can research
I can find the answers
Who's credible? Who isn't?
Where are ideas consistent?
Where are they not consistent?
What are my classmates telling me?
It's learning to weed through information
and picking the choice stuff
and this isn't for anyone else *but me*.
(Interview 2)

Figure 5: Paula found poem

Paula - Sharing Authority

Like Glenda, Paula would be considered a “non-traditional” student because she was in pursuit of her undergraduate degree after starting a family and working. Again, we see that Paula came to the figured world of sustainable agriculture and this course after some considerable reflection about searching for fulfillment. In addition to majoring in sustainable agriculture, Paula minored in sociology, which she explained was because of her interest in people, even though she is “shy.” Her story of finding inspiration from the food in the break room at the bank and the experiences she had throughout her life were particularly powerful for us as we learned from Paula. Especially since she describes herself as “not a risk taker,” the gravity of pursuing a career path in agroecology and food system work represents some of Paula’s deep passion for social and environmental justice through food that motivated a number of our students.

Paula shared a number of her experiences in formal education during interviews and expressed a deep discontent for the way things are, but was unsure of how to take any type of action to make change in the flawed system. We found the section about her evaluation of professors she has encountered especially powerful because it captures her emotions as a student investing in higher education (“I’m paying a thousand dollars for this”) and at the same time questioning the realized value of witnessing someone “present Power Points and talk.” To be clear, Paula was not reflecting on the instructors in our course in that segment. But when reading this poem, it is likely to question the type of teacher or professor *you* have been, and we wanted to elevate Paula’s concerns.

Paula’s parents immigrated to CA and her family lived in an urban area before moving the Midwest to start complete her degree program. The stanza about “Instant

Lunch” (a quick to prepare noodle soup in a Styrofoam cup) again featured the transformative motivational influence of healthy food on Paula’s life and was an example of her ability to take action and prioritize food for her young child and family.

Like Margaret, Paula’s shyness in class seemed to be bound to her described lack of confidence or authority in agricultural practices. While Paula brought many funds of knowledge to the classroom, she also regularly questioned her ability to bring anything of value to the group, which initially led to feelings of anxiety regarding the structure of the course. Because each week students independently researched a topic related to an agriculture decision-making context and reported back on that topic, students like Paula felt vulnerable as their ideas and analysis skills were put on display for the rest of the class. In the initial interview, Paula talked about the challenge of not knowing how much research should be done on a particular topic and the pressure of presenting these ideas to an intimidating group of instructors and students whom she felt had much more authority than her. It should be noted that Paula earned the highest grade in the course and consistently produced the most thoroughly researched prompts as well as some of the strongest written analytical work of all of the students. Even though this process was challenging for Paula, by the end of the semester, she realized that despite the challenges she had in the course – the sharing of epistemic authority helped her see how these assessment practices were not “for anyone else *but*” her. In the context of that quotation, Paula was making the point that *she* was benefiting from what could have seemed at the time to be “busy work.” Her line of questioning about “who’s credible?” and “who isn’t?” and the confirmation that she “can find the answers” indicates to us that the course helped empower her to gain authority by practicing researching, proposing, and crafting

arguments about agricultural management decisions that were self-directed and self-validated. Sharing authority with students like Paula is one of the features that we believe can lead to scientific identity formation. The design of the assessments required students to take on diverse decision-making roles to address local agriculture problems and they had to learn to draw on their own laminated expertise.

Scaffolding Social Justice

The last theme, scaffolding social justice, is featured throughout the stories of our three participants. Each of our participants interested in a career in agroecology were working in the direction of social justice, but also expressed an overall anxiety about the lack of resources or opportunities to meaningfully pursue these visions. This is the unfortunate reality for a number of learners who might seek fulfillment beyond “the almighty dollar”, as Glenda puts it, or look for an opportunity to use science in pursuit of social justice and sustainability. However, this gap in the interests and passions of students to do “meaningful” work and the lack of job opportunities in this area is reflective of a serious challenge in our current global economy. After being fired from a job that left Paula unsatisfied and searching for “fulfillment” she found agriculture and has an interest in working for a “sustainably minded” company. After graduating, she is still looking for jobs despite her strong history of academic achievement and stellar analytical skills. Margaret came to the course after witnessing a fundamental contradiction when a food scientist was dreaming of ways to make more profit off of processed foods for impoverished customers and realized that food scientists were missing some critical components to viewing problems of food equity and access. Glenda returned back to college after a 35 year hiatus (wherein she helped raise 12 children and

establish a State Organic Agriculture Association) to see what was happening in the “main stream” and to hopefully find employment off her small farm.

Taken together, the lives and stories of our participants were telling us that they were looking for ways to embody identities of advocates for social justice while also meaningfully applying scientific knowledges. In analyzing the assessment practices in the course, the community of practice supported learners as they assumed identities of sustainable practitioners by making decisions and leveraging their voices to help merge scientific identities with the identities of social justice workers. It is important to note, however, that we intentionally left out language of social movements and social justice in this course that was meant to emphasize management practices. However, after better understanding our students and what they were looking for out of this course and experiences beyond this course suggest that we might consider thinking about additional ways to **scaffold social justice** through our science assessment practices.

Discussion:

We argue that agroecology is an F-STEM discipline because of its fundamental concern and value of local, situated knowledge, a general position of advocacy and social justice (Kloppenburg, 1991) and because women are more likely to participate in these alternatives to industrial agriculture. This discipline is on margins in the realm of agriculture, not because a lack of productivity, but because of incommensurability with the narrowly capitalist and hegemonic ideals associated with agriculture industries. That being said, a career trajectory in agroecology does not promise a ticket into the middle class; instead it promises ongoing sacrifice to pursue what is morally and ethically virtuous despite the fact that it might not be as economically rewarding. However, its

practitioners are applying the knowledge and practices of STEM through agroecology to directly advocate for ecological justice and social justice.

Cutting across all of the themes from our findings is the value of local knowledges and the expertise of teachers *and* students to make decisions in diverse contexts to best meet their needs. As mentioned earlier, agroecology is unique in its disciplinary concession that a deep understanding of an ecological context (Vandermeer & Perfecto, 2013) that people like “old man Joe,” the fictional character that Glenda authored, should have the authority and agency to make decisions about how to best manage natural resources. Kloppenburg (1991) draws on the work of feminist sociologists of science (Harding, 1991) to position alternative agriculture (agroecology) as a discipline dependent upon alternative ways of knowing that have roots in feminist epistemologies. Further, he makes the case that these positions are especially marginalized in our industrialized economic and agricultural context.

What we all know as scientific knowledge has attained virtually undisputed intellectual hegemony, while local knowledge has been pushed to the epistemic peripheries, its utility so poorly recognized that we have a difficulty even labeling it. (p.529)

It is precisely this type of local knowledge that is essential for instructors to leverage in order to make decisions that are responsive to the diverse needs of learners in a variety of situated contexts. In our context within an upper level core course, there were a number of ways that we not only tried to encourage students to develop the type of scientific knowledge that is embedded in the *local*, but the instructors also enacted their *own* local knowledge of learners to carry out assessment practices that were meant to both expand and accommodate learner identities.

The instructional decision to allow flexibility in terms of how students decided what areas to study and represent their local knowledge gave students control of these decisions so that they can participate, to the extent possible, in ways that suited their particular affinities. Calabrese Barton and Tan (2009) have argued that one way to support youth science identities is through studying different “hybrid spaces” that bring together funds of knowledge and discourse between different figured worlds (classroom, after school, home) (p.67). In their study, they highlight pedagogical, political, and physical spaces that were flexible to permit these hybrid spaces to exist to allow students to engage in the world of science. Gonsalves et al. (2013) provided similar opportunities for middle school girls to *re-figure* their experiences in science with the flexibility of an afterschool science club. The assessment practices that we analyzed included flexibility in terms of the curriculum, which included issues that students found compelling, as well as their ongoing choices and autonomy as learners. For each decision case, the learners developed researchable questions for the classroom community to consider (e.g. what are the geological features that influence water quality in the region?) and were able to pursue questions that they found interesting.

In one instance, Paula opted to research a topic that was understudied and quickly realized the limits of the existing knowledge related to the micronutrient demands of fruit trees. She explained the process as “hitting a wall” and felt like she was going to “let down” her classmates by showing up without much information about the particular task at hand. In this scenario, Paula elected to explore an area that was outside of her comfort range and divulged the pressure of the classroom community looking to her for expertise to address the issue in the case. These types of independent investigations on topics with

scant primary literature provide an interesting opportunity for students to experience the boundary of scientific progress, but make them vulnerable to feeling as if something is wrong with *them* because they are not able to find an *answer*. It is unclear how to best support learners who encounter these types of dilemmas in science classrooms, but it is evident that these types of experiences can elicit emotions of not belonging within a particular figured world (Holland et al., 1998).

It is possible for students in this situation to question the structure of a course that does not readily offer answers to students. This reorientation to share authority with students is in part a way to encourage learner agency, but students might not fully understand or be willing to assume this new role. Within the realm of science, however, the elevated status is partially maintained by holding hegemonic control over the rules for acquiring epistemic authority (Harding, 1991; Kleinman, 1998). These discussions around sharing epistemic authority are not trivial because there is the possible fear that it might lead to a diluted integrity of a particular discipline or way of knowing. Certainly, however, in our assessment practices we can find better ways of learning to share epistemic authority with our students, especially upper-level college students, to overcome challenges that are nested in the issue of the identity gap for women and non-dominant groups (Tan et al., 2013).

Perhaps the least controversial of our themes, laminating voices, is also the hardest to document and support. Margaret, a high achieving learner who came to the class with a strong background in sciences, was able to assume voices of a soil scientist, weed scientist, and agronomist and laminate these with her interest in ecological sustainability and food access within and outside of the classroom community. However,

it is unclear whether or not this literacy and fluency was attained through practices and engagement in material during the course or whether or not she brought these “voices” with her. Other students might represent these voices in written work (e.g. Paula) while others might be better at using these voices in classroom discussions (e.g. Glenda).

Additionally, while we hope that providing learners with opportunities to engage with diverse individuals and diverse resource management contexts (vegetable farm, federal advisor, row-crop farm, etc.) will help build these voices, what happens if students really do not show any affinity or interests in adding voices to their already layered identities? For example, we do not have much evidence that Glenda expanded her perspectives related to conventional agricultural practices or saw more nuance in the ways to address ecological issues nested in industrial agriculture.

Conclusion

We have brought to light some challenges with the contemporary emphasis on STEM education that narrowly focuses on career preparation while disregarding some of the broader visions of science education. We have highlighted literature from critical feminist scholars who have opened up spaces for researchers to address issues of access and ownership in science education and STEM fields. Additionally, the issues of equity embedded in science assessment practices and the affordances of sociocultural views of learning to aid in the enactment of equitable assessment, highlighted the importance for science education researchers and instructors to consider the complex process of science identity formation.

We have taken up the position that one of the purposes of science assessment practices should be to support the formation of scientific identities. Further, we have

argued that focusing on the embodiment of Feminist – STEM identities while pursuing feminist science disciplines like agroecology is a necessary transformation for the field of science education. Figuring out how to best support the formation of these identities through equitable science assessment practices was the focus of this qualitative exploration. We have used the lives, experiences and voices of three women in an Agroecology course and poetic representation to help identify four features of ESAP that support F-STEM: (1) allowing flexibility, (2) laminating voices, (3) sharing authority, and (4) scaffolding social justice. All of these features of ESAP that we describe have strong roots within decades of feminist perspectives on science education, and democratic and critical pedagogical practice in general. However, we understand that each of them is contentious within the figured world of science classrooms.

For decades, researchers and philosophers of science have been looking for ways to leverage feminist perspectives in science education to help make progress towards social justice. We have taken a similar activist position within the world of science education and have looked to the stories of three women pursuing careers in an F-STEM discipline, agroecology, to better understand how to support scientific identity formation through equitable science assessment practices. Consistent throughout the lives of these women is their interest in participating in a community of practice that is working in the direction of social justice and ecological sustainability. Our students' aspirations to use science to learn how to better care for people and the planet can only be realized if teachers and researchers consider ways to scaffold science education for social justice. From a pragmatic perspective, focusing on increasing learner access to conventional STEM disciplines that have historically marginalized women and other non-dominant

groups while exploiting natural resources in pursuit of innovations that lead to accumulated wealth and power is an understandable place to begin but not a place to end. We hope to further redirect science education to accommodate broader visions of science education that are in the direction of social justice and global sustainability but we understand the political and cultural barriers deep within the nature of science and educational institutions that make this vision problematic (Calabrese Barton, 1998, 2001; Calabrese Barton et al., 2003). Instead of focusing on recruiting and retaining talent to STEM fields, we might be better suited to look at ways to transform STEM fields to accommodate diverse perspectives and local knowledges of feminist sciences like agroecology. This requires an approach to science assessment practices that goes beyond supporting access to science and aims to scaffold learners as they assume new identities as equitable scientists.

CHAPTER 4: BECOMING BERMUDA GRASS: MAPPING AND TRACING RHIZOMES TO PRACTICE REFLEXIVITY

Bermuda Grass

This article describes a process of becoming Bermuda Grass. Deleuze and Guattari's (1987) concepts of *mapping* and *tracing* are used to make new meaning of Bermuda grass, a rhizomatic weed encountered by the authors in a community garden. We explore an *identity of non-participation* (Wenger, 1998) in this narrative, reflexive, and rhizomatic analysis. By mimicking Bermuda grass, the authors creep into and move beyond a research context in a sustainable agriculture course in a large, Midwestern Land Grant University. This manuscript is an experiment and product of the authors as they represent their experiences of reflexive analysis that ruptured from the classroom to uncover personal and global spaces within the sustainable agriculture social movement and provide insights with implications for education research on equitable assessment practices. Layered stories (Tamboukou, 2008) and Finlay's (2002) typology of reflexivity are used to help capture the performed identities of researchers and researched to help *trace* this process of *mapping*. Overall, we argue that mapping is a way to embody Bermuda grass and tracing is a way to capture the embodiment of this reflexive practice.

Quit Gardening and Write your Dissertation – August, 2013

“Do you really think I could join the course?” Mike asked. He stood up with a fistful of Bermuda grass rhizomes that he and Chris were pulling from an overgrown strawberry bed in a community garden in midwestern college town, and threw them into a growing pile of the noxious weeds.

“Yeah, definitely. I’ll talk to Helen about it,” Chris replied nonchalantly, and reassured Mike that even though Mike did not have the prerequisites for the course, he would hopefully find it engaging. Helen, an assistant professor in rural sociology, was the instructor of record for the course. Chris helped redesign the Advanced Practices in Sustainable Agriculture (APSA) course to feature equitable assessment practices around compelling socioscientific issues (Presley et al., 2013; Sadler, 2011) and real cases from local farms (Stanford et al., 1992). Chris knew it would not be hard to convince Helen to let Mike join the course. The class was nowhere near full – representative of the marginal status of sustainable agriculture at a university that is sometimes taunted as “Monsanto – U”. Mike later enrolled in the sustainable agriculture course two days before class started and consented to participate in Chris’ dissertation research.

Chris wondered whether or not it would be ethical, useful, or problematic to have someone like Mike whom he had a personal relationship with - as neighbor and friend – be part of his dissertation research on the course. Both Chris and Mike continued pulling out the Bermuda grass rhizomes. One used a heavy handled forked hoe to break up the thatches and the other tried to separate plant material from soil – sometimes latching onto a rhizome that can run under or grow through a strawberry plant.

The course was designed for someone like Mike who was deciding whether or not sustainable agriculture was *for* him by providing opportunities to explore management strategies and tradeoffs related to the environment, economics, and quality of life (Galt et al., 2013). Even though Mike grew up in the suburbs and was actually a registered nurse at the university hospital, he always had an interest in growing food and building a healthier food system. Pulling Bermuda Grass is a typical chore for newcomers to urban

and community agriculture like Mike. He started working in this urban agriculture project to decide if he could really justify a career change to a profession that is rife with uncertainty and has significant barriers to entry for newcomers, especially someone who did not come from significant money or whose family did not already own land. Mike was taking more responsibility in Demonstrating Community Agriculture (DCA), a community-based urban farm that Chris had been managing for the past three years while working on his doctorate at the nearby Land Grant University (LGU).

Chris was trying to transition out of this role and some of the responsibilities he had as garden manager and reluctantly take the advice of one of the retired faculty members in his department. During an annual review, Chris was he should “quit gardening, and write his dissertation.” The whole room of faculty members in his department laughed. Chris laughed along, too, and he thought about this often while pulling weeds in a number of the urban agriculture plots he managed in town and on campus – when he probably should have been writing. However, for Chris, this work in the garden, pulling weeds, provided numerous opportunities to study Bermuda grass, and learn to embody its persistence. “Man, how could we be more like Bermuda Grass?” Chris joked, “I wish that we had a better use for it, because it grows like crazy.”

Mapping Rhizomes and Becoming Bermuda Grass

This manuscript embodies Deleuze and Guattari's (1987) description of *mapping rhizomes* to guide reflexive research practice. The stories of a researcher (Chris) and the researched (Mike) are presented to uncover the complexities of *identities of non-participation* (Wenger, 1998) within an advanced practices of sustainable agriculture classroom community. From the previous section, it is clear that Chris and Mike are directly intertwined through a shared experience in their neighborhood and the class

setting that elevates the importance of reflexive practice (Berger, 2013). This relationship is further explored through a layered account of the authors' shared experiences in and outside of the APSA course that began in the fall of 2013. Together, they learn from Bermuda Grass and become the rhizome that they fervently tried to remove from their urban farm.

Is this On or Off the Record?

An interview was conducted during the end of the semester, in December of 2013. As mentioned before, Mike and Chris were neighbors at the time. This interview occurred in Chris' living room. This segment was from the forty-third minute of the ninety-minute end of the semester interview. During this section of the interview it became apparent that Mike felt as if the ideas that he brought to the classroom learning community – the class Chris encouraged Mike to join - were not valued, which led to challenges identifying with and participating in the class (Lave & Wenger, 1991; Wenger, 1998).

Chris: Uhh, were there any instructors that you tended to agree or disagree with more often?

Mike: Is this on or off the record?

Chris: Uhh, I mean, it could be off the record if you want. It's on the record now. I could make it, I mean...(interrupted)

Mike: Um, yeah, uh, [pause] I, I don't, know. I guess [pause] not really (both laugh). On a personal level, like I don't know. What would you say? What, what's the question addressing is it like on a personal level you didn't agree with a professor or...(interrupted)

Chris: I mean, I think everything comes down to a personal level. But just like on, in terms of uh, the statements that they said or how that – how that connected to kind of how you viewed the world or anything like that. And in terms of what they'll see –right now, Helen is the only person on the IRB. It's possible that eventually some of the other professors will, will be. But even what Helen will see is not going to be with your name directly associated with it.

Mike: In terms of transcripts as well?

Chris asked the opening question in this excerpt to get an idea of whether or not any of his research participants experienced any tension or conflict with the several instructors in the course. Mike's question of whether or not "this is on or off the record," suggests some concern about whether or not he can speak candidly, and indicated that there was likely a professor that he did not connect with for one reason or another. Chris and Mike share a laugh after Mike adds, "I guess not really," because his body language and hesitation indicated he was not sharing transparently. Chris backpedals a bit, sharing the process of confidentiality and risk minimization connected to the IRB process and later explains that identifiable information will not be shared with any of the research team, like Helen, who had authority over Mike. After being reassured, the conversation continues:

Mike: I mean, generally, actually, overall I didn't take any opposition with any of the professors in terms of like what they were saying and what they were teaching us - and their viewpoint on a lot of agriculture. Um, I felt like personally a little dismissed by Helen. A lot of the time. So, I was often pretty frustrated when I would speak up. I just felt like she kind of was like "alright," and moved on immediately to another point and never elaborated off any of my ideas, which I felt kind of devalued them, for whatever reason. And that was with Helen and only Helen (muted laugh)

Chris: Hmm

Chris reflected a year later during transcribing that in that moment, he did not know exactly what to say in response to Mike. This exchange became particularly interesting for Chris, because in a later interview with Helen, she explained that she felt like Mike was one of the strongest students in the course and on, "a different level" than the other students. After revisiting this section of the interview during the transcription process and the initial stages of writing Chris' dissertation, it was relevant to explore what Wenger

(1998) would call an *identity of non-participation* further using reflexivity (Finlay, 2002) and the practice of *mapping* and *tracing rhizomes* (Deleuze & Guattari, 1987). However, this makes it seem as if it was a choice, but it was more that Chris later acknowledged that his thought process and his collaboration with Mike and Helen and his dissertation advisor was an embodiment of mapping and reflexivity that yielded a transformative learning experience to better understand how to meet the needs of learners through research and teaching. Together, the authors aim to convey these experiences through a shared narration of this practice.

Mapping Rhizomes, Reflexivity and Identities

"We're tired of trees. We should stop believing in trees, roots, and radicles. They've made us suffer too much...Many people have a tree growing in their heads, but the brain itself is much more a grass than a tree" - Deleuze & Guattari (1987), A Thousand Plateaus: Capitalism and Schizophrenia, p. 15

It is worthwhile to expand Deleuze and Guattari's poststructural *rhizome* and situate this perspective within a selection of theoretical and philosophical views of social change through a lens of reflexivity, sociocultural learning, and identity. We first make the assumption that *all* research is connected to processes of social change and that interpreting human experiences in educational institutions – especially marginalized disciplines like sustainable agriculture – requires a broader understanding of the political, economic, and cultural context (Lave & Wenger, 1991) of that setting. This broad understanding or mapping of the landscape is afforded by attending to the *rhizome* (Ogden, 2011).

Within the first paragraph of their introductory chapter in *A Thousand Plateaus*, Deleuze and Guattari (1987) explain that their identities have merged together in the process of writing their book by claiming, “since each of us was several, there was already quite a

crowd.” This disruption initiates the dissociation of the structural concept of a core ‘identity’ that minimizes the multiple personalities and voices that all individuals bring to their participation in the social world that is much more rhizome like than tree-like. For example, the authors of this paper are teachers, researchers, farmers, nurses, pragmatists, activists, and learners all merged into one author trying to convey an experience that resonates with a crowd of readers who similarly hold multiple identities.

Deleuze and Guattari are some of the most well known poststructuralists (also see Derrida (1972) and Foucault). They hold what Gee (2001) refers to as *Institutional - Identities* from their positions within the disciplines of linguistics and psychoanalysis, but they are not afraid to draw connections between diverse disciplines in their analysis and critique of many other fields of study for their “tree-like” tendencies. In the quotation we selected to precede this section, Deleuze and Guattari contrast a world that views consciousness as ‘trees,’ rather than a rhizomatic grass. We interpret this to mean that the dominant practice of favoring structured approaches to explain natural and human phenomenon as reified in texts, knowledge systems and entire disciplines, is marked by an attempt to separate and reduce realities rather than accept the interconnectedness inherent in human and natural ecosystems. Deleuze and Guattari find this practice of “making trees” harmful if it is not fervently connected back to an awareness of the connection between humans, nature, and knowledge. While it is difficult (impossible) to describe a meta-narrative of a poststructural paradigm, the best approximation might suggest that the reduction and division that happens in structured attempts to understand and address issues in the world - making trees - fails to ameliorate and possibly exacerbates global issues of equity or social justice. These efforts are problematic,

especially as they relate to supporting learners in equitable classroom communities that are meant to support identity formation and full participation (like the course under study). As an example, the type of structural oversimplification and corollary marginalization in the veil of scientific progress exemplified by the phenomenon of high-stakes standardized assessments is harmful because of the meaning and decisions that are made based on the knowledges researchers in that field construct. Literature suggests that while there are many different purposes of assessments (i.e. for learning, evaluating learning, differentiating students, etc.), policy makers at federal and local levels have increasingly relied upon student performance as measured by standardized tests as the most efficient way to gauge student learning and even evaluate school performance.

The scientific research of advanced psychometrics and rasch modeling are some of the most advanced techniques to validate test items as fair arbiters of achievement. However, tests and the performance of testing play out in political, economic, and cultural contexts. The assessments are meant to provide a way to facilitate educational meritocracy but can ultimately result in the further oppression of students. For example, students from lower socio-economic status might not be able to pay for, or even know about, test-preparation materials or courses that are known to significantly improve test performance on exams like the SAT. The tests themselves might selectively bias performance because of a lack of the researchers' and assessment designers' cultural self-awareness. Fusco and Barton (2001) point out that the science of assessment research is a human endeavor that has been used to construct an achievement gap that might be more reflective of issues of poverty rather than meritocracy. Further, social institutions use testing metrics to justify decisions related to funding and career trajectories. Teachers

place a high value on their students' scores on these tests. An experience that stuck with Chris was his dedication to "raising student achievement" during his stint as a middle school science teacher. Chris "taught to the test," without *only* teaching to the test because he hoped it would somehow lift his students out of poverty and oppression. Teachers and principals belaboring the importance of testing (because their jobs might depend on it) could lead students to believe that they will become a 'nothing' if they perform poorly on these tests (Reay & Wiliam, 1999). Because the "trees" of standardized testing are meant to be elevated, through scientific objectivism, above the cultural contexts in which they exist, the tree fails to address the realities embedded in the under resourced communities. In this way, standardized testing can act as a tool of an oppressive education system. In their research, Chris and Marcelle hope to provide assessment strategies that support all learners, and are especially concerned with supporting scientific identity formation.

According to Deleuze and Guattari (1987), much of western thought is categorized into distinct collections of nodes that are branched but have a fundamental tendency towards "binary logic" that "has never reached an understanding of multiplicity" (p.5). In the previous section we fall into the same trap, trying to *otherize* the practice of high stakes testing through our narratives (Sikes, 2005). Deleuze and Guattari find this problematic because it leads to a separation between the human condition and a connection to nature. Perhaps, it is more important to consider the ways that through our actions or inactions as researchers on assessments we contribute to those realities.

We dedicate space now to attempt a summary of a rhizome that has inspired our

reflexivity. Deleuze and Guattari (1987) clarify that a rhizome has principles of (1) *connection*, (2) *heterogeneity*, (3) *multiplicity*, (4) *asignifying rupture*, (5) *cartography*, and (6) *decalcomania*. The first two rhizomatic principles of connection and heterogeneity mean that “any point of a rhizome can be connected to any other, and must be” (p.7). A collection of symbols, as in a sentence or narrative, cannot just be merely broken into its component parts, but must be connected to the outer world. These symbols cannot be perceived separately from a layered political or social context. By extension, then, the principle of *multiplicity* suggests that a rhizome does not differentiate between subject and object. As an example, they describe a puppet string in concert with the puppeteer and the woven nerve fibers and other increasingly smaller and interconnected dimensions of anatomy and physiology that cannot be constituted separately.

Next, *asignifying rupture*, means that, “a rhizome ceaselessly establishes connections between semiotic chains, organizations of power, and circumstances relative to the arts, sciences, and social struggles” (p.7). Any collection of symbols in written language, for example, evokes an unending and unpredictable experience of differential meaning making as ideas and connections bubble up in the diverse consciousness of readers. As any reader interprets a given sentence, there is a rupture that moves from the symbols on a page or screen and connects to an unknowable collection of images or ideas that are not easily resolvable or communicated in any type of linear, or tree-like fashion; however, these are valuable notions that are fundamental to the ways humans construct meaning.

Instead of ignoring these rhizomatic notions, Deleuze and Guattari propose *embodying* them and using this interconnected and layered self-awareness through the

principle and practice of *mapping* and *tracing*. Here we find resonance between the practices of *mapping* and reflexivity in qualitative research (Holland, 1999; Lincoln & Guba, 1985). Deleuze and Guattari (1987) first dichotomize the practice of *mapping* and *tracing* by elevating the practice of approaching experiences in the natural world as a map maker would, rather than merely capturing a picture or making a trace. It is this performance of making a map that Ogden (2011) experiments with in her ethnographic landscape of the people and wildlife in the Florida Everglades. Ogden argues that the value of making a map is that once it has been constructed, it can be viewed or interpreted in many different ways. This is similar to the orientation of researchers like Tamboukou (2008) and Plummer (1995) who argue that one of the values of their narrative paradigm is that readers are meant to take on an active and interpretive role, making their own meaning of aspects of the stories. We view *mapping* as the embodied action of a researcher (or anyone else for that matter) as they negotiate a world of symbols, make meaning of those symbols, and take action. Therefore, people are constantly *mapping rhizomes*, but the paths taken and connections made between collections of symbols with variable meanings are not easily represented in text.

Similarly, the practice of reflexivity in qualitative research is ongoing, but narrating these experiences for a broader audience is challenging. It is widely agreed that everyone should practice reflexivity (Finlay, 2002). However, the constructed representations (*tracings*), modeled after the *mapping* experience is difficult to write and will always be an external and imperfect copy of that embodied reality. Authoring a meta-narrative might be a way to better approximate this messy practice, as a way to represent what is going on in an author's subconscious and in the process represent some

greater truth or confessional tale (Maanen, 1988), but even these tracings are editorialized or sensationalized mis-remembrances of experiences *mapping*. We are obviously subject to this same criticism and limitation in our present work. Our next section, reads like traditional, structural, ‘literature reviews’ in academic journals following some form of ‘introduction’. Much of what is reified in our text rests on a rich network of theory, philosophy, and history. It is a *tracing* of theory and research on the subject of reflexivity and identity. Each of these concepts has multiple meanings in the many different human sciences and philosophical traditions from which they arise. This section is meant to provide readers with a collection of perspectives and previous work related to the topic at hand, while also signaling to the reader who we are as authors and how we view the world.

Literature Review: Tracing Trees and Mapping Rhizomes

This section briefly describes some of Chris’ understanding of the philosophical movements within the study of social change to identify the trees, or existing knowledge structures. This *rupture* connects back to Deleuze and Guattari and poststructuralists that aim to move in multiple, layered, and unpredictable directions with their notion of the *rhizome* in seeking progress towards social justice and equity. The section focuses briefly on the concepts of reflexivity and identity that connect with the referenced research in sociology, cultural studies, ethnography, and critical science education.

Some of the earliest social psychologists, like G.H Mead (1934) argued that “reflexiveness – the turning-back of the experience of the individual upon himself” is the “essential condition, within the social process, for the development of mind” (p.134). This ongoing process of self-awareness involves reflection upon who learners are, where

they are, and the extent to which what they do is connected to others and other natural resources on the earth (Holland, 1999). Sociologists of Late Modernity, like Giddens (1991) argue that there are two types of reflexivity that are part of individual and social processes of change. First, there is the type of reflexivity that is reproductive or reflective - mirroring or maintaining a particular structure or knowledge system. Second, there is reflexivity that looks beyond these structures and asks to what extent are these structures valid, equitable forms of social or conceptual arrangement? Then, in light of the best available evidence, people make decisions that hopefully help empower individuals to actively rebuild or reconstruct a more just society. One challenge is deciding what counts as the most appropriate form of evidence to inform these reflexive choices, especially in an age of mass information and the power of institutions to construct knowledge. Society changes, then, as individuals and collectives participate in this game of replication, assimilation, permutation, or improvisation. This happens through acts of reflexivity, which are ongoing and is one way to form and reform individual and group identities. These broad perspectives in sociology provide a lens to begin to understand how groups of people change over time and why these changes are important.

Lave and Wenger (1991) challenged the worlds of education, anthropology, and sociology with their contribution of what they intended to be a sociological learning theory. In other words, they provide an analytical toolkit in their seminal work on situated learning to help explain how groups of people change over time in diverse, situated contexts. In addition to cognition, Lave and Wenger describe learning as more of a process of becoming an 'old-timer' in a community with a shared practice. Individuals come to various communities as 'newcomers' and they make meaning of the work that

they do through the relationships and interactions they have with near peers and experts, or ‘old-timers’. Situated learning theory was empirically grounded in apprenticeship models of learning in non-industrial, non-school based contexts. This provided an opportunity to think outside of the norms and language of learning focused on acquisition of discreet knowledge or skills, and focus on a process of learning to assume identities of a community of practice. Wenger (1998) reimagines education as a focus on supporting identity formation. As mentioned earlier, one of the biggest barriers to identity formation is the extent to which an individual is given access to membership and can imagine and author an identity of participation. This lens permitted Chris to see that Mike had an *identity of non-participation* related to the sustainable agriculture course community and initiated this analysis.

Critical science education researchers have contributed significant work in the area of scientific identities by looking for ways in which learners from marginalized backgrounds are made to feel as if they can become a member of a scientific community of practice (Birmingham & Calabrese Barton, 2014; Calabrese Barton et al., 2003; Calabrese Barton & Tan, 2009; Calabrese Barton & Tan, 2010). This previous research emphasizes the extent to which learners from underrepresented groups make meaning of their experiences in school and out of school and come to feel as if science is *for* them (Calabrese Barton et al., 2003). Much of this research applies Holland et al.’s (1998) concept of *figured worlds* and *improvisations* to highlight the sociohistorical aspects of identity that restrict the types of identities individuals feel as if they can assume. We are particularly interested in these improvisations that people embody as they try to make

sense of who they are and what they can do, in response to what the external structures like race, gender, and culture in these *figured worlds* are telling them they can do.

The figured world of qualitative research values the practice of reflexivity and offers a number of tools to help enhance authenticity or uncover certain truths (Coffey & Atkinson, 1996). Here, we do not attempt to review the history of reflexivity as it applies to qualitative research, but heavily lean on the synthesis work of Finlay (2002) and Holland (1999). Holland focuses on the importance of paradigmatic assumptions (Kuhn, 1970) that are made throughout the research process and outlines four levels of reflexivity. Holland describes level four reflexivity as, “the kind of enlightenment we seek at the end of the pathway to radical reflexivity,” he continues and claims it “is not simply another paradigm; it is a way of handling and transcending the interminable debates which have laid down disciplinary and paradigm boundaries” (p.476). In this view, reflexivity can ‘transcend’ the divisions between disciplines that can also happen through an experience of *mapping of rhizomes*. This ability to see beyond a particular paradigm is an example of the type of liberated thought that can come from rhizomatic analysis. Similarly, Finlay (2002) develops a ‘typology’ of reflexivity and explores how these five different types of reflexivity can be used in service or disservice of qualitative research. Table 5 outlines these five reflexivities with a brief description using selected quotations. This “map” of reflexivity is meant to help researchers decide which aspects of reflexivity are most pertinent to their practice.

Table 5: Five types of reflexivity. From Finlay (2002) the five types of reflexivity in qualitative research practice with supporting quotations

Type	Description
Introspection	<ul style="list-style-type: none"> • In addition to examining one’s own experience and personal meanings for their own sake, insights can emerge from personal introspection which then form the basis of a more generalized understanding and interpretations (p. 214)
Intersubjective reflection	<ul style="list-style-type: none"> • Here, researchers explore the mutual meanings emerging within the research relationship. They focus on the situated and negotiated nature of the research encounter and, for those of a psychodynamic persuasion, how unconscious processes structure relations between the researcher and participant (p. 215)
Mutual collaboration	<ul style="list-style-type: none"> • Recognizing research as a co-constituted account, adherents of participative research argue that as research participants also have the capacity to be reflexive beings, they can be co-opted into the research as co-researchers (p. 218)
Social critique	<ul style="list-style-type: none"> • One particular concern for researchers using reflexivity as social critique is how to manage the power imbalance between researcher and participant (p. 220)
Discursive deconstruction	<ul style="list-style-type: none"> • In reflexivity as discursive deconstruction, attention is paid to the ambiguity of meanings in language used and how this impacts on modes of presentation. How, researchers ask, can we pin down and represent the dynamic, multiple meanings embedded in language? (p. 221)

The history of reflexivity is embedded in the fields of social psychology and sociology and provides strategies to explore the human condition and constructions of self and society. Starting in the seventies, reflexivity gained increasing popularity in the practice of human sciences because of a hope to enhance validity and be aware of the ways that researchers can directly impact the lives of those they research. In this context we ask, how can reflexivity be practiced through mapping rhizomes to interpret and

deconstruct barriers to assuming an identity of participation in a classroom community of practice?

Methods/Mapping/Findings

One of the challenging aspects of learning to write narratives in qualitative research is that a methods section is missing or seldom includes any semblance of the reality of what data collection, analysis, and writing looked like. This is our methods section but also a reflexive narrative of our improvisations, mappings, and findings. We also include a description of background and research context before narrating our experience *mapping* related to exploring identities of non-participation.

Improvisations/Inspirations:

We answer our research question by attempting to communicate how we used reflexivity and mapping to uncover and remove barriers to participation for Mike and future students like Mike. We were moved by the work of Carol Rambo Ronai (1998, 1999) and Pete Sikes (2005) because of the way they constructed layered notions of identities that show the blurred line between the researcher and the researched. In two articles that, "are and are not" written in two parts, Ronai uses Derrida's non-concepts of the "mystic-writing pad," "mimesis", and "sous-rature" to push the boundary of how to represent identities and practice reflexivity in her research of, and with, exotic dancers. We model our vignette on her post-structural narrative ethnographic style.

Pete Sikes warns of the challenges of 'otherizing the subject' in his reflexive narrative of his visit to a school for children with special needs. Therefore, we were inspired to connect ourselves to the context rather than separate ourselves. In other words, following the rhizome deeper using the connections that we have to the social

world in an attempt to actively participate in a process of social change towards more equitable learning environments. This is best represented by the recruitment of Mike into this work as a co-author and later conversations with Helen, debriefing conversations, and emails that have led to the current status of this manuscript. Ken Plummer (1995) and his work on "coming out stories" resonated with us because to some extent the act of identifying as a member of the sustainable agriculture movement is, in a way, coming out as queer. Surely, not to the same magnitude or scale, but just like the other narrative researchers, we are focusing on a counter cultural or marginalized group within the dominant mainstream culture in the US. Sustainable agriculture is especially marginalized at the Midwestern Land Grant University context in which the study took place. Both Mike and Chris have thought continuously about the challenges of sharing with their parents, grandparents, friends and families that they are considering a career in sustainable agriculture after considerable educational investment in a degree in nursing and biology/teacher education, respectively.

Initially, Chris hoped to write a manuscript that featured Mike's life story and his process of coming to sustainable agriculture. Chris met with Mike after conferring with Marcelle to invite him to coauthor this narrative, which initiated a series of emails talking about what ended up being an overlapping story of emergence from the suburbs, dysfunctional families, interests in public health, environmentalism, and urban agriculture to pursue a possible career in sustainable agriculture. Below is a brief email that Mike sent to Chris:

Chris,
I will sit down over the next two days and elaborate in detail about my upbringing, but I have to say that we have startling similarities. Despite our inherent privileges there's a story to be told in the

disruptive natures of our childhood pasts. I plan on sharing in detail with you, because I trust in your compassion and nonjudgmental nature, but I too fear for parts of the material's outward publication. Nevertheless, I look forward to sharing with you things I have not shared before in hopes that it will allow you to explore our trajectories in greater depth.

Best, Mike

Sent from my iPhone

Both Chris and Mike are perceived as Caucasian males, though Chris is half-Japanese.

Chris started reading the above-mentioned work in narrative research to get an idea of how to write that type of paper, and then came to Deleuze and Guattari (1987), which then initiated the writing of a different paper altogether – this paper.

Background and Research Context

This project is a commentary on reflexivity that manifested from a larger research project that Chris is leading focusing on ways to support learners in a sustainable agriculture course through equitable assessments. Chris led the redesign of the course to be case-based and emphasize socioscientific issue decision making (Presley et al., 2013) embedded in local agricultural contexts. Students practiced assuming a number of different roles within the agroecosystem to apply systems perspectives and make management recommendations that balanced environmental responsibility, economic viability, and quality of life/social justice. In this paper, we include Helen's perspectives in our analysis. Helen was the instructor of record and an Assistant Professor of Rural Sociology. The remaining participants were students from a variety of majors and backgrounds enrolled in an upper level, Advanced Practices of Sustainable Agriculture course. For the present study, Chris was particularly interested in featuring learners who were considering possible careers in agriculture but did not come from what is generally considered a 'farming' background. Chris also wanted to include an example from the

research process where the notion of a rhizome was particularly useful in helping learn more about the nature of the barriers to entry into the sustainable agriculture field. Later, after transcribing interviews and in the process of coding for a separate study, Chris noticed that Mike narrated a significant barrier to membership in the learning community and decided to follow-up with Mike and later with Helen. We try to represent this in a narrative format in the section titled Bermuda Grass. Bermuda grass is one of the most noxious weeds and a botanical rhizome that helps represent the practice of mapping that helped us figure out who we are, where we are, and how to best move forward. During this process, a number of meetings were conducted to confirm themes. Emails were exchanged to provide insight from Mike and Chris in terms of what brought them to consider careers in sustainable agriculture and some of the biggest challenges in being able to identify as a part of that social movement. With Mike's permission, Chris initiated a discussion with Helen regarding Mike feeling undervalued in class to understand her perspective on the issue and discuss ways to improve future learning environments and interactions with newcomers to the local community of practice in sustainable agriculture.

Findings

Bermuda Grass

Bermuda grass is a rhizomatic invasive plant that forms a thick mat that permeates and spreads wildly in a garden or agricultural field, where it is a perennial nuisance. In other contexts, however, Bermuda grass is drought tolerant and, if managed properly, can make a fine putting green. Bermuda grass brought Chris and Mike together – first in the Demonstrating Community Agriculture project and then later as a rhizomatic

model that was used to help make meaning of Mike's feelings of non-membership in the classroom community.. Here we continue the interview transcript from where it left off earlier:

Mike: I don't know why that is, but I was a little frustrated.

Chris: Yeah, why you felt, um, frustrated or you don't know why she would...(interrupted)

Mike: Yeah, I don't know why I necessarily felt that that's how all our interactions or exchanges went, but I did feel generally that she kind of just like dismissed whatever I had to say. The only time I felt like she was excited about something I was saying was when um, I was bringing up the carbon footprint and like methane vs. nitrous oxide, or whatever. Like. That's how specific I could be. That's the only time when she was like, "oh," like, "say more".

Mike was referring to his contributions during a teaching case titled, Pastured Energy Farm, which challenged the students to compare the overall sustainability of a conventional corn/soy bean row crop operation to a pasture-based beef cattle operation. Mike was assigned the task of exploring modeling software that can calculate the greenhouse gas (GHG) emissions of farm operations. Methane and nitrous oxide are both greenhouse gasses associated with belching beef cattle and have a stronger global warming potential than carbon dioxide. It is interesting that this is the contribution Mike recalls Helen acknowledging, because this detail is part of what makes the GHG emission comparisons complicated. Pasture operations are typically glorified in comparison to row crop systems that are regularly vilified but the longer a cow spends on pasture the more methane and nitrous oxide are released. The interview continues, and Mike talks about how it is not just in the class that he felt like his ideas were not valued, but that in the college town in general there is a "clique" of insiders who are part of a sustainable agriculture movement that contributes to a feeling of exclusivity. He justified his position by citing several other participants in the local movement, and mentioned that even

though Chris was always welcoming and open, others in the community were not. At the time, Mike knew he was on what Wenger (1998) refers to as an outbound trajectory in regards to both the classroom and the neighborhood. Unfortunately, one of the things Mike learned was that if he wanted to practice sustainable agriculture, he would have to go somewhere else.

After getting Mike's permission to ask Helen about how she felt regarding Mike's sentiments of non-participation in the class. As earlier mentioned, during her end of the year interview claimed that Mike was on "a whole different level" in terms of his analytical skills, synthesis skills and ability to craft arguments. This contrast between Mike's feelings of being undervalued and Helen's praises was particularly confusing for Chris. Nearly a year after the interview, Chris got permission from Mike to ask Helen about the situation. Nervously, and aware of the possibility that Helen could feel targeted over what was possibly just an over-sensitive reaction from one student, Chris brought up the dilemma and tried to reason through the scenario with Helen. Chris hoped that this could help Helen consider how to better meet future student needs. At first, Helen was understandably confused – taking some time to talk about how she is admittedly hard on the "city kids" and drawing associations to their propensity towards utopian or romanticized visions of agrarianism. She claimed, "I guess I want it to be complicated for them." Helen, without prompting, drew comparisons between the way she treats students from farming backgrounds and regularly brings their ideas into the classroom. For example, with the help of other collaborating instructors, she developed a two-week long teaching case based on the issue of weed resistance from one of the "farm kid's" experience. In the interview with Helen, Chris explained that after three years of

collaborating with Helen, he was just starting to feel as if his ideas were valued in the course community. He clarified that even though he has helped redesign the curriculum and built an online platform for the course, his ideas related to agriculture and knowledge of urban and community gardening were not given space. Like Mike, he felt like he did not have a voice that was valued related to sustainable agriculture.

During the meeting, both Chris and Helen continued to imagine what they could do differently, figuring out how to move beyond categories of “farm kid” and “city kid” as they try to understand how to meet the needs of students. For example, Helen said that she needed to do a better job of explaining how we are all connected to agriculture, “if you eat, you’re connected to agriculture.” Later, when Helen needed a substitute for one of her other sustainable agriculture classes, she asked Chris to possibly step-in. Instead, Chris provided an idea for an assignment that encouraged the students to reflect upon the way their family connection to agriculture has changed over the past hundred years. The idea being that even though many of the students might not have been raised on farms, it is likely that they have type of agricultural roots to the not so distant past.

In a later phone conversation, Chris and Mike tried to speculate what might lead Helen into building on and drawing out ideas from “farm kids” but leaving some of what “city kids” said to speak for itself in class. I mentioned that Helen’s position as a junior faculty member in a large, industrial agriculture minded institution consistently leaves her vulnerable to critique from other professors who might publicly ridicule sustainable agriculture. Helen goes out of her way to keep polarizing issues from dominating the classroom climate and selects her language carefully. When Helen artfully draws out ideas and concerns that students from conventional farming backgrounds holds, she is

helping facilitate a conversation between the worlds of conventional agriculture and sustainable agriculture that are otherwise not happening. When a student poses a question or represents a perspective that challenges an entrenched agriculture system, it might be strategic for Helen to disassociate herself from that view, but still take advantage of that perspective being elevated in the course. However, the downside is that students like Mike, are left possibly feeling as if Helen did not value their contribution.

Tracing What We Have Mapped

Using Finlay's (2002) typology of reflexivity we discuss some of the ways that this process of learning from and becoming more like Bermuda Grass helped the authors address an issue of non-participation within and beyond the classroom community. One of the most important things that we have learned from this experience was that the voices of participants could help lead to transformations in learning environments. For example, when Mike mentioned that he felt like an outsider in class, Chris' first reaction was disbelief. It took over a year after the interviewing and transcribing just sitting, fermenting, for Chris to realize that Mike had no reason to misrepresent his experiences in the course and in the broader sustainable agriculture community. Finlay (2002) describes this as *introspection*. It took a while for Chris to look outside of himself and look beyond his experiences coming to the local sustainable agriculture movement. Chris' role in the classroom community made it difficult for him to feel as if he was counted as a farmer, even though he was always given authority as an instructor. Therefore, it was hard for Chris to imagine that what Mike was telling him was all that important - Chris simply did not see the world in that way. However, over time and with the philosophical contributions of reflexive practice and the notion of the rhizome Chris

kept coming back to Mike's narrated experience and trying to understand what had happened and then what could be done. Failing to attend to the differences and similarities in Chris' and Mike's subject positions through reflexivity and becoming Bermuda grass would have missed this opportunity for *intersubjective reflection* (Finlay, 2002).

Through this experience Chris also learned the importance of bringing up possibly uncomfortable findings with collaborating researchers. Done in a sensitive and non-confrontational way, it allowed Chris to share some of his own feelings of insecurity as a member of the team and also allowed Helen to think about her position and the way that she influences other people who might not be like her through interactions in and outside of the classroom. Finlay (2002) argues that reflexivity can lead to this type of *mutual collaboration* where researchers “engage in cycles of mutual reflection and experience” (p. 218). This process allowed Chris to see in clearer terms who he is as a researcher and the obligation and opportunity to engage with participants in this practice of reflexivity. Researchers are perpetually calling for more reflexivity though it is challenging to find a way to represent this work as relevant to a broader audience. We hope that this represents a tangible example that can be used to justify the practice.

Mike, throughout this process has been extremely generous with his time and perspective in order for Chris and Helen to learn *from* him. In a communities of practice perspective (Wenger, 1998) everyone who is part of a particular learning environment is assumed to be learning, though they might be learning drastically different things. Through Mike's contributions, Chris and Helen were given an opportunity to learn more about themselves and the ways that student experiences in class impact the extent to

which they feel as if their ideas are valued. All learners bring funds of knowledge from their very different experiences, and it is the work of an artful teacher/learner/researcher to reflect on how those funds can be used in the general direction towards more equity and access in learning environments (Calabrese Barton & Tan, 2009; Freire, 1990). Just as there is an ongoing call for more reflexivity in the qualitative research world, there is the perpetual need to figure out how to accommodate learners into communities and mapping rhizomes is one way to facilitate this process. In this particular case, Mike eventually felt as if he needed to move to a different community because for a variety of reasons he was not able to adequately access the resources, knowledge and experience that he was seeking. He has the fortunate flexibility to make that choice to migrate through different communities that many other learners simply do not have.

The example we share shows that even something as simple as how a student's contributions in class are acknowledged can lead to unintended consequences such as inferring that participation in a community is somehow not for them. There are circumstances in which this weeding out process can be important and in some cases there are reasons to maintain strict definitions of whose ideas count as valid knowledge within a particular community. This occurrence in our experiences mapping brings to light an interesting tension and opportunity for *social critique* through reflexivity (Finlay, 2002). In this scenario, we reasoned that one of the reasons that Mike's contributions to class were not fully credited were because of some of the broader sociocultural factors and the marginalized status of sustainable agriculture at the university that was palpable for Helen and her students. This means that being a strong student in the mastery of content related to sustainable agriculture did not directly correspond to attaining identities

of participation with that classroom community of practice for Mike. This is another example of what has been demonstrated by critical feminist science scholars as an *identity gap* that is evidence by increased achievement in science by female students but disproportionate lack of representation of women in science fields (Tan et al., 2013). In our case, it suggests that there is some broader social or cultural factor that is constricting the types of identities that Mike and students like him can assume, or that Helen might bring certain culturally embedded expectations or biases that might influence the way she responds to students like Mike. For example, one manifestation of this bias could be in response to broad categorizations of students as “farmers” or “city kids.” In some ways these conventions might be helpful as an instructor to know more about how to position material and engage learners from different backgrounds, but how can instructors be sure that this does not lead to unintended consequences? For example, Helen mentioned that she wanted to make sure students who express interest in sustainable agriculture do not do so from a naively optimistic position and that it is arguably her responsibility to ground this type of student in the realistic challenges of agrarian lifestyles. However, it is also reasonable to consider a closer examination of the challenges students and instructors face while pursuing a discipline like sustainable agriculture that is part of a social movement trying to address polarizing issues of environmental degradation and marginalization.

Mike’s experiences in the course and the interactions that occurred as part of this practice of reflexivity and rhizome mapping can generate a variety of interpretations that extend beyond what we have presented here. Further, Mike’s experiences and our narrated analysis is meant to represent an example of the value of experimenting with

mapping rhizomes to guide qualitative analysis and reflexivity. It is difficult to differentiate between what we have experienced and the interpretation of these experiences as they have been replayed and revisited and expanded upon to help make greater meaning and transcend beyond the many levels of collective consciousness. The ways that we have represented our experiences required a simplification of our experiences mapping rhizomes, however, we hope that it provides opportunity for later expansion and progress towards equity without constructing knowledge claims that separate reality from research. Finlay (2002) explains that many practitioners of reflexivity are participating in *discursive deconstruction* that transcends disciplines to make new meanings. Here, Chris constructed a brief poem to synthesize the process and affordances of *Becoming Bermuda Grass*.

Becoming Bermuda Grass

Opportunistic
Resilient
Pluralist
I could cut your hands if you pull me out

Controlled
Focused
Trimmed
I could become a putting green

This poem is meant to represent the characteristics of rhizomes like Bermuda grass that are favorably mimicked through qualitative research practice. The idea that Bermuda Grass can be resistant to removal and cause abrasions insists that rhizomes, like reflexivity, cannot be easily ignored or disregarded in qualitative research. Bermuda grass is known for its use on golf courses but only under careful management. Similarly in qualitative research, this complex thatch requires careful management and pruning to create something that might have new value to audiences in a variety of different

contexts. Conveying this complexity is challenging but it can be approximated through careful tracings of experiences mapping rhizomes.

Conclusion:

Deleuze and Guattari (1987) explain, “what distinguishes the map from the tracing is that it is entirely oriented toward an experimentation in contact with the real” (p. 1). Our aim in this paper was to experiment narrating our messy process of navigating our research context. What is written is a tracing that was inspired by our experiences mapping rhizomes. For Deleuze and Guattari the point was not to compare a map to a tracing, but instead to emphasize how they might work better together. Comparing and transferring an image or tracing, back onto the mapping is a way to achieve what they call *decalcomania*. Typical research practice and their narrative products (academic papers) tend to sterilize the performance of research in the hopes of communicating a clearly organized set of ideas neatly connected to branches on trees, in an attempt to divorce or otherize the researcher from their research. However, the practice of reflexivity is readily called for in qualitative research practice as one way to authentically position and question one’s paradigmatic assumptions (Cannella & Lincoln, 2011; Finlay, 2002; R. Holland, 1999; Lincoln & Guba, 1985). Being self-aware of the impact that researchers have on realities and our participant’s identities and communities is to some extent acknowledging these rhizomatic entanglements. Learning from Bermuda Grass has helped the authors better understand their position and also consider ways to improve learning environments for future students.

CHAPTER 5: CONCLUSION

In this concluding chapter, I summarize the noteworthy contributions of this dissertation study and briefly outline some implications for future research and teaching. I begin by revisiting my intentions to explore the potential of political ecology (Robbins, 2004) when framing and enacting research on teaching in a Land Grant University. Next, I describe some of my *improvisations* (Holland et al., 1998) and experiences *brokering* (Wenger, 1998) while enacting various aspects of my dissertation. I close by explaining some possible directions for future research.

Political Ecology of Education Revisited

Throughout my dissertation process, a lens of political ecology led me to consider the complex and nuanced ways history, politics, economics and culture are at play in agroecology education and science education more broadly. In a brief conceptual article, Meek (2014) presents principles for studies on the political ecology of education. He highlights the importance of examining the way that learners come to understand their relationship with nature and environmental resources and the influence of these political, economic, and cultural factors. Meek (2015) explores the ways that agroecology education in the Brazilian Landless Worker Movement has been counter to industrial agricultural practices. He argues that “critical-place based education” employed by this social movement in Brazil helped change the way that land was ultimately managed (p. 19). Though this framework for political ecology of education is nascent and underdeveloped, drawing these connections between the inherently political practice of educating and the connection it has to land resource management is an important direction for agroecology education, sustainability education, and science education.

For this dissertation study, political ecology served as an overarching approach to guide my research in agroecology education. While I was not seeking outcomes related to observed changes in land management, political ecology helped me elevate the importance that LGUs play in learning to manage agroecological resources. When designing learning environments that support the formation of agroecological identities, there are a variety of contextual political ecological factors that might need to be considered. For example, the second chapter focuses on the types of sociocultural tensions that arise when enacting a learning environment that integrates empirically validated components of sustainable agriculture education and science education and suggests the complex and never-ending work required to engage learners who bring a variety of experiences to the classroom and participate in many different communities of practice with possibly contentious values or perspectives. In the third chapter, political ecology helped me situate the study in some of the broader political and historical context of the agroecology course and the contemporary STEM education movement and consider the ways to learn from the stories of the women in the course whose passion for sustainability and social justice encouraged me to open spaces for Feminist STEM disciplines like agroecology. In chapter 4, Ogden's (2011) political ecological experimentation with mapping rhizomes helped me make connections between reflexivity (Finlay, 2002) and rhizome theory (Deleuze & Guattari, 1987). More importantly, this connection helped me consider how barriers to membership and participation in an agroecology classroom community of practice can influence the way learners come to assume agroecological identities.

In the three manuscript chapters I opted not to evoke language of political ecology of education, though I do reference scholarship in political ecology in both the second and fourth chapter. This decision was in part due to my underdeveloped conceptions of the immediate relevance of political ecology to these educational and methodological manuscripts that I wrote. With limited space in each chapter, I opted to mostly leave out these discussions of political ecology. The themes of each of these manuscripts can help refine studies of the political ecology of education to include issues related to identity formation and community membership. I later hope to learn how to integrate these ideas into my future research, teaching, and practice and construct a more robust framework for the political ecology of education.

Improvisations

My aim here is to position some of the findings from my three manuscripts as *improvisations* that were enacted in concert with collaborators to take local and pragmatic action towards social justice and sustainability through an undergraduate science education course. It is worthwhile to reiterate that I am not saying that I was simply “making things up” from a relativist position. Improvising is a complex process of negotiating local and global constraints within which we all operate and making informed decisions that reflect identities. The combined affect of the types of identities I embody and the boundaries of those identities are dictated by sociocultural forces that act upon me in my position relative to others in a community of practice or figured world. Holland et al. 1998 argues that studying improvisations can help make invisible sociocultural structures palpable. For example, their metaphor of *the woman who climbed up the house* shows how social structures like race and class can control individuals as they negotiate

experiences in figured worlds and how discourses and metanarratives can influence action. In their story, Holland et al. recall a research participant in central Nepal, Gyanumaya, who was asked to join a researcher for an interview on the second floor balcony of a house. Because the participant was from what was perceived to be an untouchable caste, she avoided entry through the first floor kitchen, and instead scaled up the side of the house to join the researchers for the interview. The authors use this extended metaphor to present a continuum of perspectives that might explain Gyanumaya's actions that range from culturalist to constructivist. From the culturalist perspective, expectations of social class drove Gyanumaya up the side of the house, and from a constructivist position, the situation and a perception of relative "subject position" dictated her actions (p.12). I found this metaphor powerful when reflecting on the improvisations that I have made throughout the dissertation process. What houses have I been compelled to climb? What does this mean about my identities as a researcher and teacher?

In the introduction chapter, I started with a vignette where Helen explained she felt like she was "flying" in the beginning of the semester. I later argued that I viewed this work as improvising as opposed to flying. In that original context, Helen was primarily referring to some of her discomfort with the open-ended and student-driven curriculum approach for the course. In this dissertation I have argued that this novel course design was an important improvisation that resonated with previous literature in agroecology education and science education. For example, in the second chapter, I provide a review of literature in these fields that were used to inspire the framework of the APSA course. The second chapter provides a wide lens analysis of the challenges

encountered while enacting this curriculum but presents what are meant to be specific, thick examples of encountering this network of sociocultural tensions at play in the agroecology course. Because agroecology is locally integrated and social justice oriented, it requires instruction that will be responsive to the individual needs of learners. However, enacting this curriculum means that it might necessarily feel like “flying” or “jumping off a cliff” because to some extent power, authority, and ownership must shift from the instructors to the students. For Helen to be at the helm during that shift of power must have felt as if the floor had been removed from under her feet, especially since she was also coordinating the group of farmers and researchers who helped co-teach the course.

In the third chapter, this notion of improvising is important because it brings light to some of the forces propelling science education resources up houses related to STEM education reform. The prevalent discourse in the field of science education related to STEM career preparation made me feel that as a science education researcher, I needed to be able to make some type of contribution to that conversation. My improvised position on STEM reform helped situate my research on sustainable agriculture within the world of science education. First, I hope that this chapter can eventually open up space for discussions of Feminist STEM disciplines like agroecology in science education research and offer new perspectives in critical science education research. I have thought deeply about the problems of embodying a feminist identity as a science education scholar in this chapter. To some extent, it seems inappropriate for me to propose any type of reorientation for feminist perspectives from a male subject position. However, I hope that paying careful attention to the voices of my participants and my co-authors can reduce

this tension and I look forward to getting feedback from others in the field that have allowed me to consider the value of feminist perspectives in my research.

The fourth chapter might not sufficiently represent the process that I underwent creating an academic product that would help make poststructuralism relevant to my research practice. I initially was compelled to feature Mike's experiences coming to sustainable agriculture as a way to inspire others who might not come from a farming background to consider the challenges and opportunities associated with the practice of sustainable agriculture. However, I eventually opted to write to the *Qualitative Research* audience, which led me to think more deeply about methodology and eventually reflexivity and rhizomes. There are a number of papers that I still hope to write related to the data I collected on Mike and the stories he shared with me, but I was only able to feature one episode when I finally conceptualized the manuscript. However, this fourth chapter is interesting when viewed through the lens of improvisation. During the process of collaborating with Mike and later Helen I was guided by the expectation to help prioritize Mike's voice and experience to better understand issues of equity, access, and identity as it relates to sustainable agriculture education. Bringing this type of concern to Helen and then writing about these concerns at length put both Helen and me in a vulnerable position. However, embracing this vulnerability helped push all of us to learn more about ourselves and demonstrated the value of continually looking for connections and making multiple and layered meanings. This chapter provides an example of how becoming more like rhizomes can help make progress towards educational equity. This practice of mapping and becoming rhizomes permeated all aspects of writing this

dissertation and will undoubtedly help me make meaning and represent who I am as a researcher.

Brokering and Boundary Crossing

Wenger (1998) describes the important role of brokers in facilitating the transmission of ideas across communities and constellations of practice. According to Wenger, “brokers are able to make new connections across communities of practice, enable coordination, and – if they are good brokers – open new possibilities for meaning” (p. 109). I hope that the work I have done crossing disciplinary boundaries between science education and sustainable agriculture has not only opened up these new possibilities for meaning for the learners and participants in my dissertation but also for broader audiences within each field. In the science education research community, I have similarly tried to bring tools of critical feminism to studies of science assessment and socioscientific issues research. With respect to sustainable agriculture education, I aimed to bring insights from the science education research community and also contribute an example of empirical research informed by sociocultural perspectives on learning. Wenger explains that some brokers, “would rather stay at the boundaries of many practices than move to the core of any one practice” (p.110). I have experienced this challenge but assuming this broker identity and improvising ways to cross boundaries has helped me become a better learner, teacher, and researcher. In the future, I hope to continually participate in this challenging work of translation and transformation between diverse communities of practice.

Future Studies

To conclude, I present several future studies that build on the work from the three manuscripts in this dissertation. These future investigations present new opportunities to expand my identities as a researcher and teacher. In the second chapter I argue that the course, curriculum, and assessments enacted in the study presented evidence of a network of sociocultural tensions. In reasoning through curricular decisions in sustainable agriculture education instructors are faced with the challenges of anticipating the ways that a variety of actors might respond or interact with a given learning scenario while also maintaining relevance within a broader academic discipline. Genuinely taking on the challenge of engaging and supporting *all* learners in an agroecology course, then, requires a complex calculus of balancing tradeoffs, diverse content and pedagogical expertise. Perhaps most challenging is the need for ongoing curriculum and assessment design and interpretation tools to meet ever-changing needs. With new groups of students and the changing local and global contexts, responsive instruction to meet the needs of learners will perpetually require instructors to make complex decisions that only partly draw upon their disciplinary expertise. What is the best way to support instructors as they make these decisions? How can design research be used to justify instructional decision-making and contribute to learning theory? The second chapter provides an initial framework to help analyze the levels of sociocultural tensions that might exist when designing and engaging learners in real-world issues, but there is undoubtedly more nuance to be described related to the different types of tensions. For example, there might be issues that are strongly based in political positions, epistemological positions, or other aspects embedded within learner and community identities. Furthermore, each teaching

case might have the capacity to evoke different types of sociocultural tensions. It might be important to later construct a series of case studies that analyze each unit separately to look for important tensions unique to a particular topic or SSI. It is also possible that cases that feature issues related to something like climate change might result in different tensions when compared to a case on the development of herbicide resistance. Future research could further elaborate upon the types of dilemmas negotiated when framing different SSI in college science courses. In the 2014 version of *Advanced Practices in Sustainable Agriculture*, a new teaching unit was designed related to antibiotic resistance and livestock management practices. Future inquiries could focus on the series of instructional decisions that were made along the way by members of the course community of practice to help explore the dilemmas encountered when designing and implementing this SSI unit.

It would be pragmatic to further consider ways to demonstrate and document the value of the instructional and assessment practices used in the APSA course. Is it reasonable to explore the tangible benefits to these instructional strategies that could possibly justify broader reorientation of undergraduate agriculture or science courses? This presents an interesting ethical dilemma for me as I simultaneously draw upon a deeply rooted discontent for assessment strategies that merely quantify learning, but the realistic cultural and social expectation for education researchers to draw upon seemingly objective measures of academic achievement to inform broader institutional changes. Previous research in Socioscientific Reasoning (SSR) has emerged as one available interpretive framework to document the type of higher order thinking that is believed to be developed through participation in SSI based teaching and learning (Sadler et al.,

2007). In my dissertation study I collected student work samples that could later be analyzed on a normative basis to help construct some representation of this form achievement. Validating instructional practices in this way might later lead to expanded professional development opportunities for college science teachers to emphasize student-centered learning or SSI instruction.

In the third chapter I joined critical feminist perspectives with equitable assessment in search of a framework for Equitable Science Assessment Practices. The four proposed features of equitable science assessment practices that support the formation of feminist STEM identities present a variety of new opportunities for inquiry. In pursuit of a stronger framework, it might be important to consider in greater depth the challenges and affordances of enacting these four dimensions of ESAP. For example, a more in-depth analysis on *sharing authority* through science classroom assessment practices and its place in the formation of science identities could uncover important details and help further validate the model. Each of the four dimensions could later be examined independently, but there might also be noteworthy contributions looking at the emergent interplay of multiple features. Future work on assessments that supports identity formation will have to reconcile some of the dominant cultural expectation to construct validated measurements to quantify scientific identities, but instead improvise ways to support learners as they come to assume complex and ever-changing identities. While it would be possible to re-conceptualize my third chapter by operationalizing what is meant by an F-STEM identity and then using a rubric to score learners abilities to attain those skills or practices. I opted *not* to take this approach because it would inappropriately disregard the ever-changing, dynamic nature of identities that should not

be reduced to achieving certain skills. This feminist orientation that sees value in the voices and possibilities of individual learners is an important contribution to research perspectives on assessment. However, the relativist notions of identities are vulnerable to criticism as being too slippery to be empirically meaningful. Carlone et al. (2011) use the construct of “normative identities” in an attempt to make the concept of science identities less slippery by searching for the ways in which classroom environments and practices supported “being a science person” (p. 465). It would be fruitful to revisit the data and assessment practices through this lens of normative identities to help evaluate the Equitable Science Assessment Practices enacted, and also clarify the agroecological identities valued in the classroom community of practice.

After learning to become more like Bermuda Grass to harness the potential of reflexivity to help transform qualitative data, there are innumerable possibilities and implications for future research. I hope to continue to learn more about the subjectivities and privileges that I bring to research contexts to better understand how to share the stories of marginalized learners. Rhizomes and reflexivity are essential tools that will help support more in-depth explorations of race, gender, and identity that can be narrated through poignant tracings. This work has helped me identify with new movements in arts-based research to help make academics more personally and socially relevant (Leavy, 2011). Later, I intend to analyze in greater detail the lives and experiences of learners in sustainable agriculture courses who are *not* like me. From these explorations guided by reflexivity, I hope to uncover new insights into who I am and how I can support the transformation of learning environments and research methodologies to help make progress to equity, environmental sustainability, and social justice.

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APPENDIX A: COURSE SYLLABUS

Advanced Practices of Sustainable Agriculture AFNR 3315 Fall Semester 2013

Course Description:

This course is designed to further students' understanding of applied agroecological systems with an emphasis on stewarding natural resources (soil, water and energy) while maintaining an economically profitable enterprise that provides for a good quality of life. This course involves participatory action research wherein students will actively evaluate case farms during the semester. Learning experiences and resources in the course will equip students with the tools to think critically and address problems associated with the transition towards a more sustainable agriculture. The course will be organized around local and global issues of sustainable farms and farmers. Through regular reflections, you will make personal connections between diverse issues in the food system. These issues are grounded in scientific principles, but require you to practice negotiating moral and ethical dilemmas embedded in agricultural management practices. The goal of the course is to help learn to transform the food system with the science, practice, and social movement of agroecology.

Course Learning Objectives:

Students who participate actively in all class activities and discussions, carefully analyze assigned readings, and complete all assignments should, upon completion of this course, be able to:

- Demonstrate a comprehensive understanding of advanced principles of farming that sustainably manage soil, water, energy, financial, and human resources.
- Apply an agroecosystems approach to planning and managing sustainable farm operations.
- Balance decisions about everyday issues in agricultural production by weighing economic, social and environmental objectives and outcomes using an ethical and sustainable framework.
- Integrate holistic planning in managing crops and livestock in productive working landscapes that help farmers achieve quality of life and economic viability while stewarding natural resources.

Course Philosophy:

This course is designed with a community of practice philosophy. We believe that learning occurs as we learn to participate in a community of practice within particular social and cultural contexts. Therefore, learning is not a matter of merely memorizing a collection of facts or describing the relationships between concepts, but is the ongoing practice of acquiring an

evolving language, value system, and process of thinking associated with sustainable agriculture. The class is designed to be a place where farmers can come together to share issues they experience practicing sustainable agriculture and work together to consider ways to address these issues.

In the study of sustainable food systems, there are not universal truths or static solutions. In other words, we do not believe that there are “right” or “wrong” answers to the “wicked problems” that are presented in this course. However, we emphasize the need to include diverse ways of knowing and to learn from many different perspectives in order to have chance to make progress towards addressing these issues. *For this reason, everyone's engagement and participation is crucial to the success of our class.* In order to support our decision making process, we believe that scientific evidence and analytical reasoning are important tools to help us evaluate the quality of the choices that we consider. We know that moral, ideological, and ethical factors are also important in this decision making process. Ultimately, we should learn to be transparent about our value systems and priorities in particular contexts because these values influence the decisions that we make as we learn to responsibly manage resources and address problems.

Learning will happen as we create products, use tools, and make meaning of the world together. We believe that the relationships between learners in our community will help us all figure out how to make progress towards a better understanding of local and global agricultural issues. It is important to remember that all members of the course are learning together – including the instructors. The expertise of the professors from diverse disciplines will help us learn to make sense of different issues, and students will help professors learn how to communicate their expertise and make connections to real problems in agricultural practice. Whenever possible, students’ ideas and interests are taken into account as we co-create these learning experiences.

In order to ensure equitability and transparency, the products that learners create in this course will be evaluated with rubrics that clearly outline expectations for assignments. Students will help create these expectations in order to make sure that all learners understand what we value as a community. Further, it will be very important that we create summaries of what we learn after engaging in community problem solving. We will reflect individually and collectively in order to create a collection of resources that should be helpful for local farmers and future dilemmas.

Prerequisite Courses

Prerequisite: Junior standing and Introduction to Sustainable Agriculture (AFNR 2215).

Recommended: Introductory Soil Science (Soils 2100); Introductory Plant Science Course (e.g. Plant Sciences 2110, 2125 or 2075) or Animal Science Course (Ani Sci 1065, 1075).

Course Evaluation:

Students will be evaluated on weekly reflection journals (25%), active class participation (20%), collected resources and learnings from problem cases (25%) , and a semester-long project “dream farm plan” (30%). The semester-long project will consist of developing an analysis of an issue in resource management on one of the case farms you choose, using resources from class to

balance tradeoffs across environment, economy and community. Some reflection journals and dream farm plans will be peer-evaluated and peer-evaluations will count as class participation. All work will be evaluated by co-constructed evaluation rubrics.

There are a total of 1000 points possible in this course. Course will be graded on A/F basis. A = 900 – 1000 points; B= 800-900 points; C=700-800 points; D=600-700 points; F= < 600 points

Required Text and Reading Materials:

There is no text required for this course, but readings will be posted in blackboard and you are expected to read and prepare for each class.

Course Policies:

Late Work: Assignments must be turned in by 5 pm the day they are due in person or via email. Assignments turned in up to 2 days late will receive 5% grade reduction, 4 days late will receive 10% reduction, 5-10 days late will receive 15% reduction and work turned in more than 10 days late will not be accepted. Quizzes and tests must be taken on the day they are assigned, unless the student has communicated with the instructor about certain circumstances such as an university-approved field trip or activity (instructor must be notified in advance), death or serious illness of immediate family members, or personal illness. If the instructor has approved the absence, the quiz or test may be made up as arranged by student and instructor.

Assessment	Due Dates	Goals of assessment	Evaluation	% of Grade
Reflection Journals	Thursdays before midnight	Summarize the issues and problems discussed in class. Describe the problems and important contextual factors that influence ways to address the problem. Balance values of environmental responsibility, economic viability, and social justice.	Instructors and students will work to create evaluation rubrics. Each reflection will be worth 5 points.	25%
Case Objectives and Resources	Sundays before midnight	Summarize resources that are relevant to issues explored in the cases presented in class. Provide resources that other learners can access.	Each weekly contribution to the wiki page for each case will be worth 2 points and be awarded based on whether or not appropriate references are used and clearly summarized.	25%
Class Participation	In class on Mondays	Support respectful participation in class discussions. Communicate diverse perspectives on issues presented in class. Use prior experiences and resources from class to create logical arguments that support and challenge different positions.	Class attendance and equitable participation will earn weekly points. Self-evaluation tools will be used to help support individual student growth.	20%
Dream Farm Plans	Several turn-in dates for peer feedback. Final draft Due December 10 th	Create a farm plan that includes agroecological systems perspectives. Describe tool use to monitor farm system sustainability. Identify potential issues in resource management and explain how one might address these issues.	Farm plans will be peer reviewed using mutually agreed upon rubrics. The work should be representative of feasible and realistic visions for farm systems management. The farm system should be designed within geographical, cultural, and financial limitations.	30%

APPENDIX B: PRAIRIE BIRTHDAY FARM CASE STATEMENT

Background: This 40-acre farm is located on deep loess soils (Sharpsburg silt loam) situated on the summit and 3– 10% slopes of shoulder landscape positions in Clay County, Missouri. Soils are mapped as ‘eroded soil phase’ likely due to previous intensive row-cropped corn and soybean that contributed to erosion, resulting in shallow topsoil depths. A diverse production system including heirloom fruit trees, vegetables, herbs, pastured heritage chickens, honeybees, and rotation paddock horse pastures was established beginning in 1993. The most eroded site on the farm has been renovated and established with native plants as a restored prairie, which serves as nectar source for bees and habitat for beneficial predatory and parasitic insects and wildlife. The farmer directly markets to area residents and local chefs in the Kansas City metropolitan area offering heritage and wild fruit, heirloom vegetables, specialty greens, fresh eggs, and wildflower honey. She is a retired professional and educator so does not entirely rely on the farm enterprise as the sole source of family income. She uses ecologically-based principles in her sustainable farming operation and fosters education through hosting farm tours/field days, sponsoring apprenticeships/internships, and collaborating in research and education programs.

Description of Case: The farmer has implemented many sustainable agricultural practices on her farm including use of only organic amendments for vegetable and orchard production, cover cropping with native plant species in orchard alleys, on-farm production and use of composts and biochar, use of biological and physical barriers for pest control in vegetables and fruit trees (no synthetic pesticides are used), and providing non-GM grain and diet supplements such as flax for laying hens. The farmer is regularly involved in workshops organized through Missouri Organic Association, SARE, and Midwest Organic Sustainable & Extension Service to stay updated on latest management techniques and has collaborated on a soil health assessment study of her farm over the past 10 years which has included annual soil and plant tissue analyses. She has essentially transitioned to organic farming, however, has chosen not to be certified because she uses her own materials for production including a “cold-composting” process, which is likely not allowed by NOP. **The key problems faced by the farmer are correcting and maintaining sufficient plant nutrition using only organic (on-farm) sources, because plant tissue analysis often indicates insufficient or deficient content of certain nutrients and maintenance of soils at acceptable soil health levels.** The farmer has considered use of micronutrient supplements such as foliar sprays for fruit trees but only if these products are certified for organic production. She has been investigating soil amendments including worm castings and biochar prepared from various sources added to soil alone or mixed with the on-farm produced compost as ways in which to improve the nutrient quality of her produce.

1) What clarifying questions do we have about this case context?

Questions to consider:

- 1) What are the best ways for this farmer to improve and maintain soil health to support plant nutrition?**
- 2) What do we need to know before we can decide what practices help improve and maintain soil health?**

APPENDIX C: IRB

IRB: Student Consent

Dear Student Participant,

We invite you to be part of a research project on Developing Sustainable Agriculture Assessments. Chris Murakami, Dr. Mary Hendrickson, and Dr. Marcelle Siegel lead this research project.

Purpose of this Research:

The goal of this project is to understand the process of developing assessments and tools for learning in an upper level sustainable agriculture course, Agriculture 3315. Your experience as a student will help course designers understand how to better engage students in sustainable agriculture education.

Procedures:

Being part of this research involves interviews, observations, and your ongoing collaborative input. All of your course work will be used to understand challenges and successes of the assessments used in the course. The class will also be audio recorded and these recordings will be used to find important challenges. Additionally, you will be interviewed throughout the semester to reflect on your prior experiences, roles, and class expectations/experiences. There will be two, hour-long interviews that will be audio recorded and used for research purposes. Your statements given during interviews will be transcribed and a copy of these transcripts will be given to you for your records and to confirm your ideas.

Foreseeable Risks:

Throughout the research process your identity will remain confidential as much as possible. Because this research focuses on a small sample, it might be possible for your identity to be inferred, even though pseudonyms will be used in all publications. You will have an opportunity to approve all interview transcripts to remove comments as you see fit.

Voluntary Participation:

Your participation in this research is voluntary. You may discontinue participation at any time without penalty or loss of benefits to which the subject is otherwise entitled. Your relationship with the research team and the University of Missouri will in no way be compromised if you choose not to participate. If you have questions about your rights as

a human subject participant, please contact the Campus Institutional Review Board at 573-882-9585.

By signing below, you authorize the research team to include your experiences and information in the research.

Name: _____ Signature: _____

Date: _____

IRB: Student Recruitment Script

We invite you to be part of a research project on Developing Sustainable Agriculture Assessments. Chris Murakami, Dr. Mary Hendrickson, and Dr. Marcelle Siegel lead this research project.

The goal of this project is to understand the process of developing assessments for an upper level sustainable agriculture and will help create high quality tools to support learning.

Being part of this research involves interviews, observations, and your ongoing collaborative input. You will be interviewed throughout the semester to reflect on your experiences, roles, and decision-making processes. These interviews will be audio recorded and used for research purposes. Your statements given during interviews will be transcribed and a copy of these transcripts will be given to you for your records.

Throughout the research process your opinions and identity will be kept confidential within the research staff. Participation is voluntary and will no way influence your relationship with the University of Missouri or affect your grade in this class.

Your participation in this research will begin today, August 19th, 2013 and will end by May of 2014.

If you have questions about your rights as a human subject participant, please contact the Campus Institutional Review Board at 573-882-9585.

If there are any other concerns, please contact the Principal Investigator, Marcelle Siegel, at siegelm@missouri.edu or by phone 573-882-9248.

IRB: Instructor Consent Form

Dear Instructor Participant,

We invite you to be part of a research project on Developing Sustainable Agriculture Assessments. Chris Murakami, Dr. Mary Hendrickson, and Dr. Marcelle Siegel lead this research project.

Purpose of this Research:

The goal of this project is to understand the process of developing assessments for an upper level sustainable agriculture and tools developed by our group of curriculum designers. Your experience as an instructor will help other course designers understand how to better engage students in sustainable agriculture education.

Procedures:

Being part of this research involves interviews, observations, and your ongoing collaborative input. All of your participation in the course development will be used as a source of valuable data. This includes collaboration meetings, email correspondence related to the course, and the course products that you help create. The class will also be audio recorded and these recordings will be used to find important challenges. Additionally, you will be interviewed throughout the semester to reflect on your prior experiences, roles, and class expectations/experiences. There will be two, hour-long interviews that will be audio recorded and used for research purposes. Your statements given during interviews will be transcribed and a copy of these transcripts will be given to you for your records and to confirm your ideas. Your students in this course will also be recruited for participation in this study to learn from as many different perspectives and experiences.

Foreseeable Risks:

Throughout the research process your identity will remain confidential as much as possible. Because this research focuses on a small sample, it might be possible for your identity to be inferred, even though pseudonyms will be used in all publications. You will have an opportunity to approve all interview transcripts to remove comments as you see fit.

Voluntary Participation:

Your participation in this research is voluntary. You may discontinue participation at any time without penalty or loss of benefits to which the subject is otherwise entitled. Your relationship with the research team and the University of Missouri will in no way be compromised if you choose not to participate. If you have questions about your rights as

a human subject participant, please contact the Campus Institutional Review Board at 573-882-9585.

By signing below, you authorize the research team to include your experiences and information in the research.

Name: _____ Signature: _____

Date: _____

IRB: Instructor Narrative Interview Protocol

This interview will help me understand some of the experiences that you have had related to sustainable agriculture, your interest in co-creating this class, and your views on learning.

APPENDIX D: GLENDA TRANSCRIPTS

Time	Content: Interview 2, December, 2013	Speaker
0:00.0 - 0:40.1	So the two big questions that I posed in the first interview were kind of, to what extent are you content with the agricultural system and then to what extent are you content with the education system. And, I was just wondering if you could kind of rephrase some of that and paying particular attention to whether or not you think about those things differently now after this class or after this semester.	Chris
0:40.1 - 2:10.1	Umm, well I have concerns about our agriculture and our education systems and uh, ohh, after this semester of getting more education... laughs... and uh, ("air quotes") and having more courses that do have something to do with an agricultural focus of some kind, I'd say that I'm just, you know, just pretty much as concerned as I was before. I mean, you got a handful of, handful of students that I think look towards the future and realize how important our actions today and our choices are, the things that are truly upon us are in terms of sustainability and what's going to happen. But you've got a large percentage of, um, ag students here that are just going to farm the way they've always farmed - and think that there's no way it could be done any differently. And So, I mean, I mean it's possible that you know, something like this sustainable ag class should probably be a requirement for any, anybody. Anybody, I mean, for their degree. I think it's probably.	Glenda
2:10.1 - 2:11.7	Anybody in general or anybody like in an agricultural major?	Chris
2:11.6 - 4:06.9	Well let's say a sustainable ag class for somebody that's in sustainable ag. Anybody that's in any other department surely ought to have some kind of fairly intensive environmental science type refresher course. I mean even though we've been, we get subject to these things through our educational whatever, I mean, history in grade school we were taught that you know, the Anasazi's the fertile crescent the Sumerians, etc. their civilizations crashed quickly, well, because of what? Environmental degradation, whatever. So, hello?! Here we are tootling along and did anybody remember their history lessons, so now, you know, I think, I think that uh, and I see some of the, some of my classmates really see it clearer now or it woke them up. It's like wait a minute, gee you know, I didn't think about it. So, you know. I mean, putting a map of Syngenta up on a screen to actually show people where you know, gee this has been a class action suit for atrazine for all these years and Syngenta is finally going to pay out a little	Glenda

	<p>bit. It's not a lot of money but when you look at the map of the US and you see where all the dots are and you couple that with the USG survey's study and fact that we have roundup rain falling on us and it's in the Mississippi basin you can tack that to the map and you can think gee what are the externalities and what is the outcome of that going to be? Hello? You know. And it's all just going in the ocean. Ultimately, (laughs). So yeah, I don't know. I'm concerned.</p>	
4:06.8 - 4:43.8	<p>You mentioned the USGS and the kind of roundup rain and that kind of stuff. During, while I was as a researcher I was reflecting on the first class, when we brought up some of that conversation when we were I think talking about Bindweed and trying to manage it with glyphosate and whatever else and I paid particular attention to kind of the teacher's response like my response and Helen's response and the other teacher's response to that comment early on in class. Do you remember kind of how it went?</p>	Chris
4:43.7 - 4:47.1	<p>Umm.. little bit?</p>	Glenda
4:47.1 - 4:51.6	<p>Little bit with the bindweed. Yeah, why would you want to put a chemical on it?</p>	Glenda
4:51.6 - 4:55.4	<p>Yeah, but do you remember our response to your comment related to the USGS?</p>	Chris
4:55.4 - 5:00.2	<p>Umm, no. Not exactly.</p>	Glenda
5:00.2 - 5:16.2	<p>One thing that happened was I think Helen and I both looked at each other and we were just like oh well I haven't heard of that. Or you know, we'd have to look that up. So like we were very skeptical. Do you remember anything like that?</p>	Chris
5:16.2 - 7:56.2	<p>Well people don't I mean I say these things, I mean I found all this stuff while I've been in school here. It's all factual on the internet, really good sources from the US department of the interior. It's right there. This is all real stuff. I was sitting down last night, the night before last night. I was finishing up a paper it has to do with a food supply conundrum and Peter Benton's comments over in England at a century farming conference and this is for this Ag Marketing class, but it's just like I've come across so many things, like the UN report, where the front cover is "before it's too late". And they're talking about sustainability and we talk about food wastage and we talk about carbon footprint and all this stuff. I mean it's all going on. It's all going on and if you ask me, this country of ours in some respects seems to be turning a blinder eye</p>	Glenda

	<p>than most other countries in the world. And It's really sad especially when you've got these big corporations that are trying to say, use the scare tactic saying that well, if we don't do it this way with our seeds and our chemicals than there's no way we're going to feed all of these people. Well, none of these other people in the world have the money to buy somebody else's seed that they have a patent over anyway. It's not sustainable anyway, so how ridiculous is that? I mean it's just like, these are facts it's all out there we have this, this amazing internet, so you know. I mean, and the way that we talk sometimes, our country talks and people talk about other parts of the world, I mean it really kind of saddens me actually. I mean it's like the MFA, I forgot his name, he came to our class and was a speaker that you know, came, the ag econ department, reverent speaker spoke to our class, I mean his biggest concern really appeared to be that really we no longer appear to have any control over our fertilizer because it's all bought from foreign countries. So how are you going to have. (That was in our class?) No, that was in a different class. So one of his big concerns in MFA you know is a big big coop, his big concern about the future and the fact that the inputs, the nitrogen and phosphorous and stuff that you know, where are we going to get it, how expensive is it going to be? Where are we going to get it? Other countries control that supply, we don't. It's kind of scary.</p>	
<p>7:56.1 - 8:51.7</p>	<p>I agree. I brought that up just because, I mean it made me stop and think about kind of the impact that instructors have in terms of how we respond to those kind of critiques of our agriculture system. And part of the goal of the class is to show that you know, an alternative agriculture and we want to have a space where those kind of criticisms and concerns for the environment and the impact of herbicides. The impact of that on our global environment. We want to have a space to talk about that. But, I caught myself being really skeptical towards it. We found that resource and I believe we made an announcement in class, you know, and posted the USGS link. Umm, is there something else that you thought we could have done to give more space to those kind of discussions?</p>	<p>Chris</p>
<p>8:51.7 - 9:46.3</p>	<p>Well I mean, the bottom line is that those people that are going to pay attention, they'll, they'll follow it up. If somebody is really interested. Other people are going to blow it up. If you just plug atrazine settlement into your search engine, it will come right up, and it'll have that map, with you know, and it'll have the map and talk a little bit about it. I mean it's like, I know that with a lot of these young people it does appear that you really do have to have visuals. Oh yeah, if it's not a multimedia, whatever, forget it. And if it's a hands on experience, then they might get it too. But I mean</p>	<p>Chris</p>

	it's like in one ear and out the other or they're not paying attention because they're on the phone or computer anyway (laughs).	
9:46.3 - 9:53.8	So, I guess, kind of to move on a little bit. What do you consider to be the strengths of the class?	
9:53.7 - 12:20.9	I think it's an awesome class. I mean, honestly, and I told somebody this the other day, that of all the classes that I've had in all the many years that I've been in school and I've been in school a while off and on throughout the years, this is probably the best class that I've had. It is very rare that you have the opportunity to have so many, um, experts in their field make themselves willingly available to share their knowledge and to listen and continue to learn themselves in the educational setting. So, not only is, to discuss a case, or to look at things, and to get that extra knowledge or ask those questions for things that we don't know and to actually see some of those people think about comments, or think about things and share that you know, it's they're learning too. And that's really special. I mean, there's no other class, we don't have any other classes like that where it's like real. And as far as the overall amount of research and information that was, that's available that everybody shared, everybody worked really hard it seemed like. Everybody really took everything pretty seriously and really spent some time and I know different people were excited about learning different things, like wow I didn't know this. Like hey, what do you think of this or whatever. Stimulating, questioning, growing and learning, that's what education is all about. I mean, and the sharing of it. I mean, what good does it do if you're in a classroom with a hundred kids and there's no interaction. That's not education. That's regurgitation. It doesn't matter what you could spit back out on a scantron. That really doesn't measure anything. Just because someone gets 80 percent on a scantron doesn't mean they can apply any of the concepts that they have studied so hard or whatever. It doesn't mean that they could go out in the world and apply them. It doesn't mean they can, you know, have the social skills necessary to implement some idea. Or, you know, whatever. Scantrons and some of the electronic stuff just doesn't really teach. It's just another testing mode that's really I don't think equitable.	Glenda
12:20.9 - 12:29.0	In kind of, just in general, what is that you felt that you learned from the class, or is there anything that you felt like you learned?	Chris
12:28.9 - 13:54.5	Hmm. Pause. Well, I have to say that one of the things that really kind of surprised me was one of the cases when we had a case where someone had some CRP ground that they were	Glenda

	<p>contemplating pulling out of production to plant in some kind of grain or whatever. To me, that kind of blew my mind because it's kind of like. The person was educated and has some idea about sustainability and it just kind of goes against the grain of the whole entire thing. And to me that was kind of like, what? You want to do what? I mean, to me, that was just like, I mean especially because the person, I mean, how can money, money, you know, money. The person probably doesn't need money. I mean, they don't need the money. I don't, to me, that was probably the most puzzling thing to me in the class. Of the whole thing, that was just, hello? Laughs, you know, it's like I don't understand.</p>	
13:54.5 - 13:57.8	I remember in class that you were kind of incredulous or that you expressed that.	Chris
13:57.8 - 16:19.2	<p>Yeah, and I didn't have a problem expressing that because you know, I think it's sort of important that kind of idea or viewpoint on something, you know, it's not like I don't have some sort of rapport with the person also. Had it been a total stranger, I may have been a little less up front about it. Sometimes you have to be upfront though or people won't pay attention. It's like. So that was kind of interesting. Umm, I do see some of the youngsters that have come from big farms, uh traditional farms, I think I see them look at their future a lot differently than maybe they did. I mean, I see that growing. I saw a growing inkling that hey this is like a big responsibility, you know, how can what we've done, this is what we do, how can we, whatever, what's going to happen, some of that concern over more depth and understanding to sustainability and concern of course over the changes that are going to be ahead. I mean, I mean I think it's, and I just walked away from a conversation with one of my other professors, we were talking about the farm bill and we were talking about some of the people in the government think that the department of ag can just go away and the different things could be absorbed in other branches of the government and that it's not necessary or whatever, well, I mean, I still don't think anybody really understands that, that our climate our world the earth the environment, the whatever, has the upper hand all the time and if we don't, I mean people don't realize it, I mean how many times will a person rebuild their beach house where it's gotten blown away by a hurricane? How many times are they going to go back and build on the same spot? I mean, people obviously don't get. So, it's going to be interesting.</p>	Glenda
16:19.2 - 16:23.5	What were the areas of weakness in the class?	Chris
16:23.5 -	Hmm, weakness. Pause. I don't know that I could point out any	Glenda

17:51.5	particular weakness. I mean sometimes I think that maybe it got a little bit, I felt it, just personally, felt that it was getting a little bit redundant. Like on a case, coming back round, coming back round. And I know that you gotta flip it over, flip it over, flip it over, before you sometimes want to give it a good solid, you know, effort. But sometimes I felt a little bit like, I mean it's hard. I don't know so much about redundant but sometimes it just gets, it's like the last paper I wrote on the response to the food supply conundrum, and it's almost like depressing, I think that's part of it. It gets heavy for me. And it's like, huhhh, but that's, that's a part of it. One foot in front of the other. But I thought, I really thought the class over all was really positive. You gotta dig in and try to learn stuff, and I think we did a good job of trying to do that.	
17:51.5 - 18:02.7	You mentioned that it's a little redundant, or you felt it was a little slow. Were there particular cases or times in the class that you recall that?	Chris
18:02.7 - 18:42.5	I think, uh, I don't know it might have just been where I was at but when I finally came back to one of my reflection journals, I struggled with reflection journals because to me that's sometimes the structure of something that is supposed to be a reflection, you know what I'm saying. That's a little different than saying you know here it's supposed to be locked in here, whatever. But it's just like sometimes it's like, it's like there maybe some other reflections, some other, you know, avenues that. But just, it was all overall pretty good.	Glenda
18:42.4 - 19:35.7	And you're going to keep goin and growing and whatever but sometimes it was just like, as far as this is the stuff we've, to tie it back in or to keep trying to go back and pull up resources yet again, I mean that gets a little redundant to me, to me. I mean, and the last class reflection the last week, I didn't go back and pull anything out of anything. I kind of was sick that week. and tired, and it's like all semester long we've discussed these things. I mean everybody seems to get these things so not necessarily the need per se, to go back and specifically highlight, but for somebody else maybe something did really grab them. Maybe there was a resource or there was something that really made an impact, you know. that type of thing.	Glenda
19:35.7 - 19:50.1	Are you suggesting that there could be some more flexibility for students on the reflections? So like if something really, like you felt compelled to write about something that wasn't the assigned task,	Chris

19:50.1 - 20:34.5	I probably would have done it anyway, I'm just like that. I'm turning in a proposal in a class tomorrow that's not exactly like what I'm supposed to do either, but I mean I get a point reduction for it, that's okay. My brain is tired. I do not need to develop a business plan for a greenhouse because I'm not necessarily going to go to a bank with a cover letter for financing. I mean, I'm not. I seriously am trying to build this greenhouse the right way to attach it to my home for a couple different purposes. I don't need to go get funding for it. And I'm not going to go to the bank anyway. It's not sustainable. It's like, so.	Glenda
20:34.5 - 20:49.3	Where do you feel like you draw that courage, I don't know if that's the right word, but that agency or control to be able to say like, the teacher assigned this but I know that this is more important to me so I'm going to do this. Where do you draw that from?	Chris
20:49.3 - 23:17.5	My grandfather I suppose, encouraged me to ask questions and not to hesitate to question my teachers and to, um, he was a college professor, um, he ran away from home. He was given a farm upon graduation from high school from his father who was illiterate. He took all the money he had and he ended up in Ames Iowa and he lived about the cattle. Getting his first degree in Dairy Science many years later he ended up with his PhD from Northwestern at Chicago in mental health and guidance and ended up being a teachers teacher at a small liberal arts school. All the time and his love was challenging and purebred livestock and nature. So, I spent a lot of times in the woods, I spent a lot of time reading good books, I spent a lot of time going places with him, doing stuff every chance I could as a youngster. And he encouraged me to ask questions. Don't hesitate to ask questions. Don't follow the status quo, you know. Do your own thing. And it's like we're here to grow and become ourselves and not be like everybody else. Yes, I understand that you have jump through certain hoops, but, is it really all that applicable? You know, I mean if grandma makes it through the revisitation of higher math and gets that class done next semester, we'll have jumped through that final hoop, right? Laughs. And you know, I don't know, I don't know. Some of it we're just born with a little, you said what?! I don't know, I don't know. My dad was pretty outspoken, too. My dad was really proactive but he was really kind but really proactive about everything. Kind of that big picture thing. That big picture thing of , what's, looking at the whole thing and what the best proactive step forward for everybody. Not selfish, very unselfish, very giving. I really think I kind of have. That I was really blessed to have those guys in my life. I don't know, I think they made a	Glenda

	difference.	
23:17.4 - 23:31.1	Yeah, thanks for sharing that. This is a redundant question probably. But say you had a friend who's interested in sustainable or really you said any student, but would you recommend this class?	Chris
23:31.1 - 23:38.6	Yeah, I've been recommending it all the time. Telling other professors about it actually.	Glenda
23:38.6 - 23:43.4	What kind of things, similar to what you mentioned before?	Chris
23:43.4 - 25:17.2	Yeah, because I think it's important. I mean it's like some of these other people have an idea, some of them think that oh well sustainable ag is just a bunch of hooley, but some people don't. Well, it's not a bunch of hooley, it's real. We have to be sustainable. It's not, it's true it's factual. I mean. How people could not think that there are consequences to all these things that we've done and that we're doing. You know. I mean and a lot of it is financially driven. It's not necessarily, um, anything else. I mean a lot of the destructive stuff that's going on in the developed countries is totally, you know, for profit and they have the balls to try to go to other places and screw their place up too is kind of how I look at it. I mean it's like conflict of interest. It's conflict of interest, it totally is. It's like that native American quote that I put in my one reflection, you know, when we cut down all the trees and pollute all the water, you know, mess everything up, maybe white man will figure out that we can't eat money. I mean that's pretty common sensical, pretty wise. I mean.	Glenda
25:17.1 - 25:42.0	This is a hard question to answer, but this really what this study or the class is trying to figure out, but how do we get students, or how do you get learners to think outside of kind economic paradigm, or thinking only about financial capital as they make agricultural decisions. How do you think you push them to think in a different way?	Chris
25:42.0 - 27:58.4	I don't know. You've got these computers and these hand held devices and most of them go to school. I really think there needs to be more focus. You know, you have subliminal messaging, right? So what happens if you put, you know, droughty, deserty, poor people, every so often there's an image (laughs), every so often there's a thing that says. DO you know you're drinking atrazine? I don't know, I mean, the ability of people to get tunneled into what they want to do is so challenging and, and I don't know that, and the ability to step aside and say hey wait a minute. I don't know	Glenda

	<p>where that comes from exactly, but, but I mean hands on, hands on experiences. It's like with the schools and stuff if they have some kind of more hands on science program, more field trips, like say a garden or whatever. things like that can make a difference if you're studying stuff right along side of it making it more real. I mean youngsters really do like those kind of projects far more than they do other stuff. When I was a youngster, say you had to write a book report, you had a blank piece of paper, you wrote a book report, now in school some of the classrooms you could pick a template for your book report. Right there, what's happened to the learning? You know, you don't have a blank page anymore most of the time. There's always some kind of, it's like a new word, a new word for me coming back to school was "rubric". Always some kind of rubric, some kind of whatever. You know, that coloring, blank piece of paper or a coloring book. You're not going to get anything if all you've ever had is a coloring book. All you're going to have is a coloring book. Where if you have this blank piece of paper, you have no clue what someone's going to do with. I mean, they may fold it up and turn it into something else. They might not draw on it at all.</p>	
27:58.3 - 28:14.0	<p>So I mean, the interpretation that I am making is that you feel the rubric or some of the templates for a book report or whatever, that that is constricting and that constricts creativity in things like that. Is that what you're saying?</p>	Chris
28:13.9 - 29:20.1	<p>Sometimes, but at the same time if that's what, if that's how a large group of these students have been taught through school, what are they going to do if all of a sudden they don't have one. It's like, oh my goodness. What now. I mean, these independent study projects or whatever. I mean the ability to just come up with something and just do whatever you think you need to do. I mean you're always going to have somebody who is going to be a slacker and whatever, you know what I mean. And you're always going to have the person that's an over achiever and they're going to have everything tabbed and organized and polished and perfect, you're going to have the whole spectrum, but I don't know. I don't know exactly the answer to that but I think, I think that each one of us is different and each one of us has had a little different schooling or whatever, but I'm not real, I'm not real keen on a lot of what I see public schools today. I just.</p>	Glenda
29:20.0 - 29:32.0	<p>Is there anything in particular in this class that you felt like we either support some individuality or constrict?</p>	Chris
29:31.9 -	<p>I thought overall it was good. I mean, I think the class is set up</p>	Glenda

30:17.2	very very well. Because, um, you've got a lot of interaction and a lot of opportunity to hear other people's thoughts like with our class discussions and you can't grow in a vacuum. And you can't learn anything in a vacuum really. So when you're in a situation like this classroom where we all could, everybody has the opportunity to share learn ask questions, whatever, that's how real learning takes place. And you can't learn it in a vacuum. And you can't learn it in lecture where you don't get a chance to speak, write, or do something with it. I mean maybe something.	
30:17.1 - 31:05.9	Sometimes when the whole experience is done and they've taken the accumulation of everything they've learned and then they fly. I mean. they just might, you know. It's everybody does it a little differently. It's just for me sometimes, it's like last night trying to figure up this one paper, I don't know what I did but I messed up these two tables at the end of this and I hit this button a couple of times, I click click click, and it all went back to the way it started and I had everything filled out, changed and done except I lost like a corner of this thing, somehow. I don't know what I did. I said, ok, this is a good stopping place, I'm glad it's not 2 in the morning, walk away. It's like totally messes up that learning experience, laughs.	Glenda
1:00:21.8 - 1:00:42.8	Umm, I have two more questions and we're just over an hour. Were there, um, kind of conflicts or disagreements that you recall between students or between people in the class?	Chris
1:00:42.7 - 1:00:49.8	There might have been a little tension here or there but nothing that I think was too bad.	Glenda
1:00:49.7 - 1:00:51.2	What were some of the tensions that you remember?	Chris
1:00:51.2 - 1:02:31.8	It was far better than some classes. It was far better than some classes. Well I think it's kind of a matter of some people believe what they believe and they're kind of defensive about what they believe or whatever but one has to realize that sometimes in discussions it's not necessarily, cause if one chooses to make it about them, it's a choice. But if a fact of some kind or another. It is what it is. It's not necessarily about someone else and the person makes it be what it is. You know what I'm saying. It's like, you know. I don't make a big deal out of it if someone things that I'm a little weird about certain things. My viewpoint is kind of strange. It's like it's okay you know, it's going to be strange to a lot of people. It's okay. I've always been strange (laughs). People can look at me with skepticism, I mean, whatever. I mean occasionally	Glenda

	maybe some of it is like there, you know, it's okay. I mean it doesn't. I mean sometimes it helps us grow. Sometimes we might believe something and all of a sudden find out well look at this, this doesn't match up at all and then what do you do? How do you go about? Okay try the new pathway, take the new direction. I thought it was reasonable. I mean nobody went off on me or cussed at me. That's happened in another class, oh yeah. It's interesting, too. I don't really care.	
1:02:31.8 - 1:02:56.9	Do you, um, how do I put this? Do you feel like that the instructors did enough to make those tensions present or known, or how do you feel like the instructors went about kind of addressing those tensions.	
1:02:56.8 - 1:03:33.9	I think it was alright. I mean it didn't need to be made a big deal out of. I mean somebody could have chosen to bring it up more, but I think if anything had gotten more intense I'm sure something would have been said or done, but I don't think it warranted it. I think it was okay. Because I think that everyone in the class, you know, has taken something out of there. I don't see how they couldn't.	
1:03:33.8 - 1:03:38.1	One of the things we wanted to do was kind of push people,	
1:03:38.0 - 1:03:46.3	No, I thought it was good. Nobody went off. (not take them out of a comfort zone to where people shut down) Nobody crossed the line and blew up in there.	Glenda
1:03:46.3 - 1:03:59.9	Okay, um, and then. Last question, kind of a weird question, but in what ways did you feel like the course was designed for you or to support you?	Chris
1:03:59.9 - 1:05:07.2	I think it was very, you know, well very much centered on sustainable theory and choices, I mean. to have the opportunity to take each case and to remember those economy, the ecology, the social impacts, I mean, and to kinda take each thing and look at the big picture with each thing. I mean that's kind of what this sustainable track is trying to do I mean help people be able to look at it with this lens, I mean, and to continue to grow and learn and take a lot of things into account, so, I think it was a pretty good class.	

APPENDIX E: MARGARET TRANSCRIPTS

Time	Interview 1, September, 2013 Content	Speaker
0:00.0 - 0:18.9	And if you want to start just by, um, talking about how you became interested in agriculture and food system and that kind of stuff.	Chris
0:00.0 - 11:27.5	And, let's see. Oh and what do you think are the biggest strengths of our current agricultural system.	Chris
0:18.8 - 0:48.9	Okay, um, I think it first started with Tigers for Community Agriculture my freshman year. I just wanted to learn how to grow my own food and then I got more involved with other people who were doing the same thing and I really liked it. And I liked working out at Bradford. And then I started learning about our current food system and how it needs to be improved and, yeah (laughs).	Margaret
0:48.8 - 1:10.1	Okay, so, I'm just reading through your reflection right here and I'll ask you to kind of elaborate on some of the things. Um, so, you talk about kind of like a new appreciation for the hard work it takes to keep up a small-scale vegetable farm. Could you talk a little bit about that?	Chris
1:10.1 - 1:38.5	Um, yeah, I worked at Bradford all summer and we grew vegetables organically, not certified organic, but it was organic. And, yeah, I mean it's something you have to take care of every single day. There's problems you come up with. It's very labor intensive cause there's not a lot of machinery like with crops and yeah, it was, I would be exhausted everyday after work.	Margaret
1:38.4 - 1:41.9	What kind of things would you do on a regular day?	Chris
1:41.9 - 2:02.7	We have to water everything everyday and then planting is like hand planting, you bend over. Weeding, yeah, hand weeding, um, like lifting things when you're harvesting you have to lift big crates of food, or produce and just everything is manual.	Margaret
2:02.6 - 2:04.5	Yeah, and everyday you'd do stuff like that.	Chris
2:04.4 - 2:25.7	Yeah, everyday there's something like that. Like the beginning of the season is all planting, so you're just planting like rows and rows and rows. WE had tomatoes and peppers that took like two days cause there's just so many rows (laughs). And there's no machine to just place the machine or whatever.	Margaret
2:25.6 -	Right, right. And, so you said that you noticed that, you said " I've	Margaret

2:47.3	noticed that the way I used to shop before coming to school has changed a lot and it is important to me that my food was grown or sourced ethically." Could you talk a little bit about that?	
2:47.2 - 3:22.7	Yeah, um, I well I used to, I don't know. I just used to shop at a grocery store without any even thought about where my food was coming from. So now I'm a lot more aware of that. I also go to farmer's markets and I never did that before college. Uh, I like look for fair trade certified products, like coffee and stuff like that. So, it's just definitely changed. And I like buying whole foods more than processed foods, whenever I can.	Margaret
3:22.7 - 3:26.2	What is it about the whole foods or whatever?	Chris
3:26.1 - 4:11.9	Well, for me, I just feel a lot better when I eat a lot of vegetables instead of just like boxed foods. I also think about like the amount of packaging that is in processed foods like buying boxed meals and stuff like that and you definitely reduce that when you just buy vegetables and a bag of rice or something, so. And the way I eat meat has changed a lot. I don't just eat meat every single day. I tend to buy more expensive that's maybe more environmentally friendly and eat it a lot less often. Like I don't eat fast food meat or anything.	Margaret
4:11.9 - 4:27.3	And, so you talk about, um, you hope to have some role in the food system as a producer or food scientist or policy maker for the USDA. Could you talk about kind of what you want to do?	Chris
4:27.2 - 5:06.6	Yeah, I'm not sure exactly. Like, the USDA thing I could see as being later in life. Like if I was a food science, like I stayed on the science track and learned about the research that goes into it or what you find with research and then make policies based on that. Like public policies. That's kind of how I saw myself if I were to work in the food industry. But if I was to be more agriculture, I guess that would be the other side of it. I've also gotten interested in soil science, so, I just kind of have to figure it out (laughs)	Margaret
5:06.5 - 5:07.7	Cool.	Chris
5:07.7 - 5:08.4	Some aspect of it.	Margaret
5:08.3 - 5:11.1	Right, and you had that trip recently for soil judging, could you talk a little about that?	Chris
5:11.0 - 5:50.6	Yeah, that was before I even knew about it, that was awesome. I learned a lot about like, there's different types of soils within like a 50 feet radius just the horizons and the parent materials and you	Margaret

	could like see heavily farmed soils how different they are from soils that haven't been touched, so, in terms of like using our resources and using soils, it makes you realize by seeing them.	
5:50.6 - 6:06.9	So, you're one of the few students who mentioned stuff about government policies and what made you interested in government policies in particular?	Chris
6:06.9 - 6:35.7	Umm, I mean I'm still unsure about how I feel about government policies but it really affects the food environment, just like how government policies around cigarettes and that drastically reduces the amount of cigarettes that are smoked, so that could happen with food. So, it's a big deal especially in farming in general, like the way we farm. There's policies that will affect it.	Margaret
6:35.7 - 6:50.4	And then, you are food science major, and then are you a sustainable agriculture minor, and then how did you come to, talk a little bit about your experiences in food science and then sustainable agriculture.	Chris
6:50.4 - 7:15.7	I didn't like food science classes. I just felt like they were very like science based, you didn't really learn anything about the social side of food and then Sustainable Ag with like Helen's classes and I had some friends that were in Helen Hendrickson's classes and they just sounded awesome and you learn a lot more about the food system as a whole. So that's why I tacked it on, sort of.	Margaret
7:15.7 - 7:19.7	So, what kind of classes do you take for food science?	Chris
7:19.7 - 8:02.8	Um, you could go on the dairy track or the meat track or the inology, which is wine, but it's basically like chemical compounds of food and like the water holding capacity, I don't know, it was very science like, like how you could manipulate food compounds to make a product, a fast food product or something. So, it's very, yeah, it's all about processed foods mostly. There's also the food safety side, which I did like, like food microbiology. So, learning pathogens and ways to preserve food. That was cool.	Margaret
8:02.7 - 8:09.0	And when you started school, were you interested in food science initially?	Chris
8:09.0 - 8:34.8	Umm, I didn't know what I was interested in and I had someone who was a flavor chemist and like his job sounded awesome and he told me to go into food science and it's such a small program there were scholarships in it. And so I got a really good scientific background anyways, with that background, so I'm glad I did it, but I kinda went	Margaret

	into it without knowing what I was going to do.	
8:34.8 - 8:39.1	so, do you take like the intro biology.	Chris
8:39.0 - 8:42.6	Yeah, intro biology, general chemistry, organic chemistry, biochemistry all that stuff.	Margaret
8:42.5 - 8:43.3	Cool,	Chris
8:43.3 - 8:44.0	yeah	Margaret
8:44.0 - 9:05.7	Umm, so, that will take us to there will be three questions, the first two are similar, and the first one is about agriculture, and it's just, are you content with the current structure and function of the agricultural system?	Chris
9:05.6 - 9:06.7	That we have today?	Margaret
9:06.6 - 9:07.3	YEah.	Chris
9:07.3 - 9:11.2	Umm, no. (laughs).	Margaret
9:11.1 - 9:17.9	Ok, and then, you know, what are some of the strengths or weaknesses or things that you're most concerned about?	Chris
9:17.9 - 9:49.5	Like, I just feel like our agriculture system is set up to encourage people to eat more processed food because a lot of it is corn and wheat products and it's just not nearly enough encouraging to eat a diverse diet of like vegetables and stuff like that. And environmentally I think it has, could have really detrimental effects and I think we could do a lot better job conserving the environment with agriculture than we do, so.	Margaret
9:49.5 - 10:04.7	Okay, um, and, I mean, you talked a little bit about this already, but how do you hope to address some of those issues, or do you?	Chris
10:04.7 - 10:39.0	Yeah, that's like what I don't know yet. Uh, with, if I were to do a research type thing I would address sustainability of our current practice and maybe that would enforce policy changes, maybe, to make the practices more sustainable. Something like that. I don't know. I've talked to Helen about whether or not people get their knowledge from the scientists. Like do they have the power to tell other people what should be done, something like that?	Margaret
10:39.0 - 10:39.5	What did she say?	Chris

10:39.4 - 11:09.9	She was just like putting that into question, like who does have the power. She was asking me that, so I don't know. I don't know what her opinion is. Like food safety, this was an example she gave. Are small farms like safer for food safety than large conventional ones and if people, like the general public were to know, than which one would they shop more from or something like that.	Margaret
11:09.8 - 11:14.7	And then also like whether the policies better support small farms or large farms	Chris
11:14.6 - 11:17.0	Yeah.	Margaret
11:17.0 - 11:22.0	Okay, and what do you think are the strengths of our current agriculture system?	Chris
11:27.5 - 12:00.2	Definitely production because there's more calories than people per capita. So that's really good. And I guess another weakness would be distribution because there's still people going hungry, so obviously something is wrong. But yeah, production, um, I think it's good we have technology in case something bad were to happen we have these plants that could be resistant to drought or something, so in the future we're a little more prepared.	Margaret
12:00.2 - 12:16.0	Um, so this one is a little bit harder to answer, maybe, um, but it's about the education system, so, are you content with the current structure and function of our education system?	Chris
12:16.0 - 12:16.8	No, definitely not (laughs)	Margaret
12:16.7 - 12:20.0	Okay, and what...	Chris
12:19.9 - 13:02.0	I mean, like, when I came to college it wasn't in my classes it was like through clubs and stuff that I started to learn about agriculture and like where your food comes from. And I feel like that's something that we should have been learning about in grade school. And just been way more connected to our food and like agriculture. Because even if you're not going to do that with your job or something, it's just important knowledge to have, so yeah. I don't know. I just feel like the education system emphasizes like efficiency and standardized testing but life skills aren't enough.	Margaret
13:02.0 - 13:08.4	Yeah, and then, what about your experiences in higher education or at LGU.	Chris
13:08.4 - 13:26.7	Umm, I think it's like. Well, it's kind of good because it's very independent. It's like what you want to learn you can learn. There's	Margaret

	so much here. So many different things you can do, so I really like that. But if you are just going to classes and stuff, you're not going to have a very good education, if that's all you do.	
13:26.7 - 13:39.7	So then, I mean, to try to summarize what your saying, you suggest that a lot of the things that you're learning, especially about agriculture, you've learned outside of a formal classroom setting.	Chris
13:39.7 - 14:05.2	Well, yeah, and I took, I started taking more classes that weren't related to my major like the sustainable ag minor classes, so that I could learn about it. And I've definitely learned more in my classes but like if I hadn't done that then I would never, like with food science, it's just weird to me that food science has no connection to agriculture, like in all of those classes there's nothing.	Margaret
14:05.2 - 14:19.0	Do you feel like even the professors and the students and stuff who are typical food science majors, or whatever, do you feel like they think about things in similar ways or in different ways from you.	Chris
14:18.9 - 14:38.8	Yeah, they just, they, I don't, most people aren't concerned with like agriculture or the environment or sustainability. It's more like, how to, I don't want to just say make money, but that's kind of what it is. Like go to the industry and then make the food companies money.	Margaret
14:38.8 - 14:44.9	Yeah, are there any specific examples that stick out from experiences you've had in classes?	Chris
14:44.9 - 15:22.2	Yeah, our seminar classes, I think we had a speaker come in from save a lot foods, or just like an optional thing you could go see her, but she was like talking about how industry scientists are like how can you add more water to food to make it cheaper? She was like, that's the secret, just add water, water's free. And then like, so you're basically giving people a food product with more water and less nutrition and trying to sell it for the same amount but a higher profit margin. So like, that's where the concern is, the profit margin.	Margaret
15:22.2 - 15:23.1	Yeah, and how did people respond to that?	Chris
15:23.1 - 15:31.9	No one questioned it. They were just like, okay. There were no questions about it, so I thought that was a little strange. But yeah.	Margaret

APPENDIX F: MIKE TRANSCRIPTS

Time	Content. Interview 2, December, 2013	Speaker
0:02.4 - 0:42.4	So, the beginning of the semester I asked the question, whether or not you were content with the agriculture system in the US, and has this class changed the way you think about the strengths and weaknesses of our agriculture system?	Chris
0:42.4 - 3:03.9	Um, I would say it hasn't necessarily changed my overall opinion of what I think of the agricultural system, um, it did kind of, um, bring other, it brought big ag into perspective for me a little bit clearer. I really had no perception of what a lot of the larger farm processes were like before I took this class. I didn't know about a lot of the methods that large row cropping or large grazing practices used, or utilized, I would say it didn't change my opinion of what the overall flaws are of the agricultural system, um, if anything it kind of just enhanced those opinions and strengthened them, but it did help bring into perspective like the face of a lot of the big ag kids that I'll be working with or dealing with in the future. It's nice to have like these, um, like good conversations with the people that are going to be working on the other side of the industry before they take off on their rolls. So, I would say that the class was nice because I actually got to interact with people who are going to be part of big agriculture, or ag econ and things of that nature. And, it also exposed me to the ideas of like how their processes work, so, um, with the large scale process looks like when someone is cropping on 5000 10000 acres that I had NO idea about beforehand. I've only worked with like urban gardens and small scale stuff. I didn't know about the machinery, the cost to buy into those sort of things, anything, so I'd say, yeah, it just kind of diversified my knowledge of agriculture.	Mike
3:03.8 - 3:15.2	Ok, and then I asked the same question about whether or not you were content with the education system and, you know, has this course changed what you think about some of that, too?	Chris
3:15.1 - 5:37.8	Uh, I'd like to see the education system look at courses like this, and learn from it (laughs), I got a lot out of this course. Like I said in class today, I really appreciated the level of engagement within the course. How everyone was sharing their ideas and everyone was learning from one another instead of just learning from the teacher and only being allowed to learn from the teacher. I don't know, discussion was encouraged instead of dismissed and disallowed, I don't know I really appreciated that.	Mike

	<p>It's nice to, um, get a feel for what might be your field, instead again, from like one person's perspective of what's important or what should be focused on within the big concept. Um, it brings to light a lot of other issues that um, are pretty interesting. Like, I know we've had conversations in the past about discussing what - I can say names - like Lance and Chad and all those people, um, take away from the concepts we're discussing, and hearing their input kind of makes, like, it helps me kind of include and focus on a lot of other things that I would normally just dismiss in my own mind. Like the chemical cocktails, for example, like, we bring that up in class and they're like big on that. Or spraying in general, and these are things that I've always dismissed as evil, in a way. But yeah, I mean, there are times and places for these sorts of things. And, um, I don't necessarily agree fully with them, like that being the main go to, but uh, just constantly discussing and bringing up these ideas that are conventional, um, kind of, it doesn't allow me to just stop, which I feel like is a benefit to me.</p>	
5:37.7 - 5:40.2	Yeah, and you think that's partly because you have a..	Chris
5:40.1 - 6:43.1	<p>We have the force within the class, these people that are constantly acknowledging these practices and so they're always brought up and so, we can't just dismiss it and move on and only think about things from a more sustainable or like organic perspective. Um, I mean, we're working in a system that largely is not, and so, it's good to have that viewpoint in the class and discuss things from a more holistic perspective than a one sided narrow perspective which I feel you might end up getting at some of these like, sustainable ag classes otherwise. Especially classes where you have the teacher teaching the concepts and they're preaching the gospel about only being sustainable or something like that, which, I mean, this is like largely me speculating. I haven't had these classes, but I imagine that in some places you have people who are only preaching for organic practices and like, thinking this one track versus this class, which you were able to encapsulate all of the different ideas into like one big discussion.</p>	Mike
6:43.0 - 6:54.2	Ok, you talked a little bit about, what do you perceive as the strengths of the class?	Chris
6:54.2 - 7:41.8	I mean, again, I think all of us learning from each other and nobody necessarily stepping up to be the primary teacher, um, is the large benefit of the class. We have facilitators that keep conversation somewhat moderated, just so it doesn't tend to lead	Mike

	into one side of the discussion and not allow for others to speak up. Yeah, I think having multiple moderators is a good idea for this sort of class. Um, can we come back to that and I could think about it more.	
7:41.8 - 7:50.4	Yeah, and the other side of that, what are the weaknesses of class?	Chris
7:50.4 - 9:15.7	Umm, I'd like to personally see this class be more than 3 credit hours and maybe more than 3 hours throughout the week. I think it's a really important class and I think that if there was more time to have the class, I know it's probably way more responsibility for you to have something like this be a 6 hour class rather than a 3 hour class, but, I think that this class would be more effective if we had more field visits to a lot of the farms and could really put these farms into a lot of perspective in a different light when we've actually seen and talked to these farmers ourselves, um, so I think if we could communicate more with the farmers. I thought it was really nice to go to CCUA and get a little talk with Bob, and I can't remember her name but the Goatsbeard, I thought that was nice, to actually have an interaction with the farmers that we're studying. And to walk around their farm for a bit. So, that might require that the class be 5 hours or 6 hours or something so that we aren't just stuck with the two and a half hour block each week. But, I would definitely take a class like this if it were you know a bit longer we could actually do some visits to the farm as well, in the future I would definitely take a class like this.	Mike
9:15.7 - 9:23.9	Um, and then, if you're going to take the class again, kind of as a student, what would you do differently?	Chris
9:23.9 - 10:15.7	Um, sorry, I'm thinking on a personal level, yeah, I kind of, I kind of blew off the last couple of weeks because I overscheduled myself for other stuff. I would make it a bigger priority, I would say, overall. Um, I maybe would speak up a bit more in class. I tended to just let everybody else talk a lot of the time. I had thoughts in my head and didn't speak up for whatever reason, so.	Mike
10:15.7 - 10:19.9	Ok, I mean, you said, (you're wondering why I didn't speak up?)	Chris
10:19.8 - 11:21.4	Um, yeah, I don't know exactly why. I think that goes into my own personality, but I think that often times when you feel like there's a domineering force in the class, too, that will discourage you from necessarily speaking up on some of the things.	Mike

	Especially if you're the dissenting view from that topic, which I didn't necessarily always have a dissenting view, maybe sometimes it was just already covered by that person, Laurie is who I'm talking about, of course, I really appreciated Laurie, I appreciated Glenda a lot, but often times I felt like either what I was going to say was already taken up by Glenda or I didn't necessarily want to disagree with little points because then it would be this long drawn out discussion which in the end may not have led to anything more out of it. Like getting kind of nitpicky.	
11:21.4 - 11:26.5	are there any specific things that you remember?	Chris
11:26.5 - 13:05.4	Umm, I don't know, I think that um, oftentimes like, some of the points were a bit too radical, like today she was like, well we'll just put cows on the land to really think about really put cows on the land, 500 cows on a 1000 acre patch, that's a case where I wouldn't necessarily speak up and say something that I'm thinking in my mind. Let's think about this, we could also use this and this and this. And also, I think the example was about pig weed, and so that wouldn't necessarily deter the pigweed, cows might eat other things. But, um, I think it was brought to light that cows wouldn't eat the pigweed in the first place. It's just like, I don't know, I guess, challenging the certainty of some of her answers, I just didn't see the need to from time to time. But I really appreciated her being in class because I feel like she brought a lot of things that she otherwise wouldn't have got any exposure to. She had a lot of concepts and ideas that are from like the past and also the present and she can quickly draw a reference to what she's speaking to. She's like, well, they're studying it here, in this place, that adds power to what she is saying. So, I guess it's also out of fear, because I know that she could definitely back up what she's talking about, so that might actually deter me from ever challenging her.	Mike
13:05.4 - 13:13.1	Yeah, ok, do you feel like there were any other folks, or other disagreements or tensions in the class that existed?	Chris
13:13.1 - 14:10.2	Totally, yeah, everytime Glenda would speak, I would see Chad and Lance and all of them, like smile, or roll their eyes, I mean, not every time but occasionally, and sometimes, I always sat next to those guys or towards that end of the table. Because I liked them, they were really nice people. And uh, I don't know, I mean you could definitely get the feel like there's tension in the air when Glenda would bring up this radical organic concept and Chad and Lance and them would think, well this isn't at all	Mike

	applicable to our farming practices, so like, pause, I don't know it is too extreme for us to consider in their minds, and so, and then. Laurie's probably thinking that your farming practices are destroying the earth, so it's interesting to watch it all unfold.	
16:34.0 - 16:47.9	You know, it was kind of by chance that you got the recommendation by me to take the course. What were you expecting going in and what did you get?	Chris
16:47.9 - 17:50.0	Uh, I was expecting students to be like, um, way more advanced than me in their understanding of agriculture. And I would say that I didn't necessarily find that to be true entirely. They have a lot more background in terms of like the things they've learned in college, because this is my first ag class, but I didn't feel like I was really far behind by any means. I felt like I could follow along in class with anything that was being talked about, um and if not I just tended to jot something down in my notebook and I would look it up when I got home. Which is part of my personality, I'm not going to raise my hand and ask about a tiny concept or something, so, yeah, I'd rather just look it up when I got home. I could jot down what we were talking about when it came up and I can think through that later.	Mike
49:12.1 - 51:06.8	I think I have a fair understanding of what resilience means. But can you tell me what you were trying to achieve with the focus on resilience? And what you were hoping people were taking away from it?	Mike
51:06.7 - 52:30.7	Yeah, I don't think that we got to what we were looking for and Helen hinted at that a little bit today. (That's why I'm asking you). Right, so in terms an ecological understanding of resilience is the idea that there are redundancies has a negative connotation but I think that that's part of what we're looking for in terms of making sure that the food system or particular organisms and relationships are resilient in terms of they could endure stress or disturbances and things like that. We didn't get to that in the class in the way that we expected the class. We didn't talk about resilience in terms of social resilience, um, and cultural resilience and things like that that would have opened up a different dimension that might have been really useful but I don't know if the instructors, if we were willing to go there at that point. What were some of, what would you have like to have seen in that case, or in that discussion or whatever?	Chris
52:30.7 - 53:40.4	I think with resilience we could have segued into a discussion on efficiency. I think that like you're saying there are a lot of	Mike

	<p>redundancies there comes an inefficient nature, but that inefficient nature also makes it resilient. And so we could talk about like, um, efficiency as a whole, kind of in regards to big Ag production. And even small ag things, too. How the quickest answer to beat a problem or deter something isn't necessarily always the best. I think that, I don't know. We could have. Resilience is a pretty broad topic so we could have tried to do much different things. I don't know if that make sense but Nature in and of itself is redundant and resilient, otherwise we wouldn't be here.</p>	
53:40.4 - 54:20.0	<p>Yeah, that gets to some of the views of nature that I think that Glenda has, I know that Glenda has, views of a resilient nature and being able to emulate that model in agriculture which is some of the fundamental views of agroecology (like permaculture), but in terms of a lot of the other instructors in the class willing to take that position or willing to talk about resilience in that way, I don't know that, you know. They're willing to do that in that particular setting.</p>	Chris
54:20.0 - 54:23.5	<p>Because of their own stances on it?</p>	Mike
54:23.4 - 54:49.4	<p>I don't know if it's their own stance, or that that stance evokes the rolled eyes in a lot of cases. Or it's speaking in a language that is not really well understood. It doesn't mean that we shouldn't do it. I don't know.</p>	Chris
1:05:44.5 - 1:06:02.3	<p>Were there any instructors that you tended to agree or disagree with more?</p>	Chris
1:05:53.3 - 1:05:54.4	<p>Is this on or off the record?</p>	Mike
1:06:02.3 - 1:06:07.2	<p>I mean, it could be off the record if you want. It's on the record now. I could make it, I mean,</p>	Chris
1:06:07.1 - 1:06:16.9	<p>Uh, yeah, I don't know. No, I guess, not really (laughs)</p>	Mike
1:06:16.8 - 1:06:21.8	<p>This is how I'll do it is that.</p>	Chris
1:06:21.7 - 1:06:31.6	<p>On a personal level, what's the question addressing like on a personal level you didn't agree with a professor or?</p>	Mike
1:06:31.6 - 1:07:06.2	<p>I mean, I think everything comes down to a personal level, but in terms of the statements that they said or how that connected to how you viewed the world or anything like that. But in terms of what they'll see, right now Helen is the only person on the</p>	Chris

	IRB. It's possible that eventually some of the other professors will be, but even what Helen will see is not going to be with your name directly associated with it.	
1:07:06.1 - 1:07:10.4	In terms of transcripts as well?	Mike
1:07:10.3 - 1:07:23.1	Especially for things that are like naming names and stuff like that, or contentious issues.	Chris
1:07:23.1 - 1:07:24.2	But this transcript will be attached to the rest of what I've said?	Mike
1:07:24.2 - 1:07:33.4	There will be sections, like it's going to be broken up into sections.	Chris
1:07:33.4 - 1:08:16.1	Generally, actually, overall I didn't take any opposition to any of the professors in terms of like what they were saying and what they were teaching us and their viewpoint on a lot of agriculture. I felt like personally a little dismissed by Helen, a lot of the time. So I was often pretty frustrated when I would speak up. I just felt like she kind of was alright, and moved on immediately to another point and never elaborated off any of my ideas which I felt kind of devalued them, for whatever reason. And that was with Helen and only Helen. I don't know why that is, but I was a little frustrated.	Mike
1:08:16.0 - 1:08:17.0	Why you felt frustrated or why she would...	Chris
1:08:16.1 - 1:08:53.4	Yeah, I don't know why I necessarily felt that that's how all our interactions or exchanges went, but I did feel generally that she kind of dismissed whatever I had to say. The only time I felt like she was excited about something I was saying was when I was bringing up the carbon footprint and like what methane vs. nitrous oxide or whatever. Like. That's how specific I could be. That's the only time when she was like, oh, say more. or like elaborate on that idea. Vs. other students, that she would be a little bit more engaged by the things that they had to say.	Mike
1:08:53.3 - 1:08:59.9	Yeah, so I'm just hearing, from that context, she might be able to figure out that it was you.	Chris
1:08:59.8 - 1:09:27.9	I mean, I don't think that she was prejudiced against me, but, um, for whatever reason when I would say things, I don't know. I haven't had other classes with her and I don't have any other connection to her outside of class, some of the other students do have more of a personal relationships with here. Where they've met with her in her office and they share some other sort of, like connection.	Mike

VITA

Christopher Daniel Murakami was born to Tami Jo Corvello and Daniel Mitsuo Murakami on October 1, 1985 in Castro Valley, CA. After graduating from Castro Valley High School in 2003, Christopher went on to earn a Bachelor's of Science in Biological Sciences at the University of Southern California in Los Angeles, CA, in 2007. Chris taught 8th grade physical science in north east Los Angeles for three years before moving to Columbia, MO, to pursue his masters degree in 2011 and later his PhD in Learning, Teaching, and Curriculum with an emphasis in science education. At the University of Missouri, Chris was the founder of the MU Children's Learning Garden - an outdoor classroom for children to connect with food and nature – and completed his dissertation research on the development of an undergraduate sustainable agriculture course. Chris is married to Dr. Erin Rae Pearson and the father of Josephine Pearson Murakami.