DESIGNING, TEACHING, AND ASSESSING AN INNOVATIVE ONLINE SCIENCE CURRICULUM FOR EFFECTIVE STUDENT LEARNING

by

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DEDICATION

My Capstone Project is dedicated to my lovely wife for all her soulful support, MSSE for their inspiration, dedication, and excellent education, The Blackfeet Community College's students and staff for their willingness to collaborate, learn, and cultivate a better world, and our earth for all the beauty she grows.

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GLOSSARY

Agroecology: “Applying ecological concepts and principles to optimize interactions between plants, animals, humans and the environment while taking into consideration the social aspects that need to be addressed for a sustainable and fair food system” (FAO). Furthermore, “Agroecology is a scientific discipline that uses ecological theory to study, design, manage and evaluate agricultural systems that are productive but also resource conserving” (Agroecology in Action).

Agroforestry: “A working-tree farming system that integrates crops or livestock—or both—with trees and shrubs. A well-designed agroforestry system results in biological interactions that provide multiple benefits, including diversified income sources, increased biological production, better water quality, and improved habitat for both humans and wildlife” (Beetz, 2011, p. 2).

Biodynamic Agriculture: Also known as “Biodynamics is a holistic, ecological, and ethical approach to farming, gardening, food, and nutrition” (BDA).

Organic Agriculture: “Organic is a labeling term that indicates that the food or other agricultural product has been produced through approved methods. These methods integrate cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity. Synthetic fertilizers, sewage sludge, irradiation, and genetic engineering may not be used” (USDA, 2011).

Regenerative Agriculture: “Farming and grazing practices that, among other benefits, reverse climate change by rebuilding soil organic matter and restoring degraded soil biodiversity – resulting in both carbon drawdown and improving the water cycle” (Regeneration International).

Sustainable Food Systems: “A food system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised” (Nguyen, 2018, p. 1).

Traditional Ecological Knowledge (TEK): Also known as “Indigenous Knowledge or Native Science, (hereafter, TEK) refers to the evolving knowledge acquired by indigenous and local peoples over hundreds or thousands of years through direct contact with the environment. This knowledge is specific to a location and includes the relationships between plants, animals, natural phenomena, landscapes and timing of events that are used for lifeways, including but not limited to hunting, fishing, trapping, agriculture, and forestry. TEK is an accumulating body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (human and non-human) with one another and with the environment. It encompasses the world view of indigenous people which includes ecology, spirituality, human and animal relationships, and more” (USFWS, 2011).

GLOSSARY CONTINUED

Traditional Ecological Knowledge and Wisdom (TEKW): "Knowledge of ecological principles, such as succession and interrelatedness of all components of the environment; use of ecological indicators; adaptive strategies for monitoring, enhancing, and sustainably harvesting resources; effective systems of knowledge acquisition and transfer; respectful and interactive attitudes and philosophies; close identification with ancestral lands; and beliefs that recognize the power and spirituality of nature. These characteristics, taken in totality, have enabled many groups of aboriginal [Indigenous] peoples to live sustainably within their local environments for many thousands of years" (Turner et al., 2000, p. 1275).

ABSTRACT

Many educational institutions have transitioned to online learning, opening opportunities and demand for creative, innovative, effective, and engaging online environmental science curricula. Therefore, I designed and taught an online Brightspace (D2L) science course. Student and staff study population were affiliated with Blackfeet Community College in Browning, Montana. A mixed methods research design assessed the curriculum's effectiveness for student learning; results indicated that students were positively impacted, gaining a greater understanding of scientific theory and praxis. This study significantly empowered me as an educator and can serve as a resource to construct online science curricula.

INTRODUCTION AND BACKGROUND

Context of the Study

"It's like building the plane while you're flying," remarked my good friend and fellow educator, during a recent conversation over the phone. We were discussing the current state of affairs, in light of the Coronavirus and how educational institutions at large were scrambling to transition from face-to-face education to online courses. Hence as we collectively enter a new era of reality, stemming from the Coronavirus's global effects, certain things will hopefully return to normal. However, many believe educational institutions, at large, will transition from face-to-face education to online courses. This presumption is based on the pre-COVID trend that online education has become increasingly common in higher education (He et al., 2019). Additionally, He et al. (2019) suggested that "designing, developing, teaching, and assessing" an online course effectively is a large obstacle, but not insurmountable (p. 101). In fact, this is exactly what I did for my Master of Science in Science Education (MSSE) capstone project; I designed, virtually taught, and assessed an online science curriculum for effective student learning.

Currently, there is a great demand for effective and engaging online environmental science curriculum, especially curricula tailored towards specific sciences that support sustainable food systems, biodiversity, and climate change mitigation and adaptation. The purpose of my MSSE's capstone project was to test out an innovative online environmental science curriculum that I designed. During the spring of 2021, through a partnership with the Blackfeet Community College (BCC) in Browning, Montana, I virtually taught my six-week long course titled "Food Sovereignty, Native

Food Systems, and Agroecology" to BCC student and staff. Moreover, I assessed how effective both my facilitation and course content were for student learning.

Given that my capstone project plan was to construct an online natural science curriculum focused on the science of agroecology, it was essential to have a solid conceptual foundation in agroecology. Simply put, agroecology is the scientific discipline concerned with how to grow healthy food holistically in an ecological manner. Agroecology shares many of the same principles and practices of organic, biodynamic, and regenerative agriculture.

Broadly speaking, an Indigenous Research Methodology is conducting research within a particular Indigenous community following that specific Indigenous community's codes of conduct while honoring their "systems of knowledge and worldviews" (Wilson, 2008, p. 8). Thus, given that my sample population of students were Blackfeet Tribal members, I felt it was vital to understand and incorporate, as best I could, an Indigenous Research Methodology to conduct my action research in a culturally appropriate manner. One common difficulty in cross-cultural communication is finding common ground, and yet, the communication process depends on it to bring about a shared understanding (Wilson, 2008). In the following sections, my intent is to cultivate a common ground to illuminate the meaning of an Indigenous Research Methodology. I integrated knowledge derived from Indigenous Research Methodology and applied it during my student interviews by first developing respectful and reciprocal relationships.

This study has a clear, immediate, and broader significance in addressing the necessity of student learning, absorption of scientific concepts, and how to apply them in

a local context. There are very plausible positive impacts that can result from this study. More specifically, carrying out this capstone has jump-started my career as an educator while simultaneously providing students quality environmental science curriculum. Hopefully, my study will serve as resource guide for other teachers, particularly online facilitators, in the "how to" of constructing an effective online science curriculum.

Focus Question

My focus question was, What are the outcomes of designing and teaching an innovative online science curriculum?

My sub-questions include the following:

1. To what degree do students understand the science concepts taught?
2. What are the attitudes of participating students towards this online science course?
3. In what ways has this impacted me as a teacher?

CONCEPTUAL FRAMEWORK

Prior to our global pandemic caused by the Coronavirus, He et al. (2019) illuminated the educational trend of academic institutions transitioning from face-to-face to an online learning environment in the following manner:

> Online teaching and learning have become increasingly common in higher educational institutions. These higher educational institutions realize the growing importance of online learning in information systems/information technology (IS/IT) education and are now offering online IS/IT courses and programs to students (p. 101).

Furthermore, it is difficult to effectively design, develop, teach, and assess an online IS/IT course (He et al., 2019, p. 101). Therefore, to successfully overcome this challenge, Collison et al. (2000) made the following compelling case for effective online education:

> As more corporate and educational institutions move online in search of quality instruction or training, it's essential that professors, teachers and other course designers, as well as the facilitators who will actually lead virtual communities, consider several alternative methods and tools available for effective online moderating (p. 2).

While elucidating the breadth and potentiality of conducting online learning in information systems/information technology (IS/IT) education, He et al. (2019) poignantly pointed out that this type of research is still a budding field of research, where "new methods, techniques, and emerging technologies" will improve online education (p. 104). Ultimately, student success in online courses is dependent on effective faculty and access to the technology. Therefore, it is imperative that instructors of IS/IT (i.e., online courses) learn the best practices of online teaching for student success (He et al., 2019, p. 101).

Theoretical Underpinning

Agroecology

While agroecology is considered a natural science this "perspective tends to privilege positivist science and Cartesian reductionism over other ways of knowing (e.g., holistic, indigenous, or local knowledge)" (Méndez et al., 2015, p. 8). Moreover, agroecology is a conceptual framework developed from Indigenous knowledge systems, i.e., Indigenous ways of knowing and being with local ecologies, derived from peoples with intimate relationships to land, soil, animals, plants, and the cultivation of food (Méndez et al., 2007, p. 11).

Agroecology originated in the early 1970s from an ecological and agronomic interpretation and has since evolved into a into a transdisciplinary field of study grounded in participatory action research (PAR) via the cooperation between "social scientists, agricultural communities, and nonscientific knowledge systems" (Méndez et al., 2015, p. 4). Leading academics in the field of agroecology, Gliessman et al. (2017) defined agroecology as "an approach that seeks to integrate ecological science with other academic disciplines (e.g., agronomy, sociology, history, etc.) and knowledge systems (e.g., local, indigenous, etc.) to guide research and actions towards the sustainable transformation of our current agrifood system" (p. 1). This specific definition incorporates a "transdisciplinary-oriented agroecology" which is an integration of various knowledge systems in order to discover and develop solutions to the issues presented by the current agrifood system (Méndez et al., 2017, p. 1).

It must be emphasized that agroecology is an action-oriented effort which strives to effectively aid in the reconfiguration of the "current agri-food systems toward sustainability" (Méndez et al., 2015, p. 5). Furthermore, agroecological transdisciplinary approaches and participatory action research (PAR) are "emerging and dynamic frameworks of research and praxis" (Méndez et al., 2015, p. 7). Agroecology, in a sense, is a method manifested as "a science, a practice and a social movement" most efficacious when there is a convergence of these three realms (Méndez et al., 2017, p. 1).

As mentioned above, agroecology is a transdisciplinary approach, meaning that it both values and integrates different types of knowledge systems, including but not limited to the following: academic, scientific, local, indigenous, or experiential (Méndez et al., 2015, p. 5). In addition, agroecology "incorporates a critique of the role of prevalent political–economic structures in the construction of the current agri-food system" (Méndez et al., 2015, pp. 4-5). More importantly agroecology is an effort which strives to move our food systems toward localized sustainability.

Following a transdisciplinary manner frequently develops into the embodiment of a problem-based focus (Méndez et al., 2015, p. 5). Recognizing the significance of having research that is applicable to the local context, i.e., solving local problems, is the aim of participatory action research (PAR). The PAR approach involves a diversity of participants that are engaged in a cyclical process of "research, reflection, and action" (Méndez et al., 2015, p. 5). The PAR process also aspires to involve and broadcast the voices of disenfranchised populations "traditionally excluded from the research process" (Méndez et al., 2015, p. 5). For example, the PAR method maximizes mindfulness of the

marginalized voices from groups, such as rural/Indigenous women, Indigenous people, farm workers, and small farm holders (Méndez et al., 2015, p. 7).

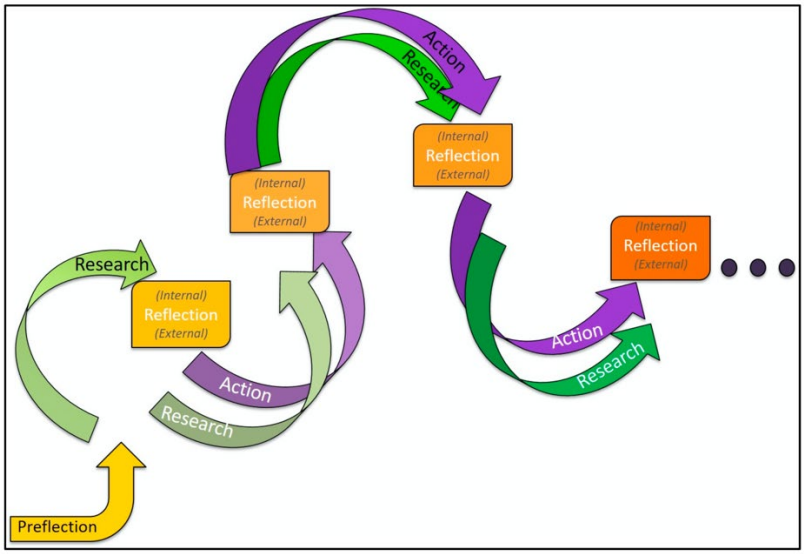


Figure 1. The iterative participatory action research (PAR) cycle (Méndez et al., 2017, p. 2).

There has been an increase in the appeal of synthesizing agroecology and the PAR process over the last decade (Méndez et al., 2017). In an ideal PAR project, stakeholders during early stages of the research process collaborate and engage in "iterative dialogue" to explicitly determine a project proposal that encompasses stakeholders' "needs, capacities, and methods" (Méndez et al., 2015, p. 7). The PAR process is closely intertwined with an "action-oriented agroecology," because both recognize the fundamental value in learning from and interacting with ecological and social diversity (Méndez et al., 2015, p. 7). Where it may be difficult for some, it is necessary for people collaborating, to learn from and with other knowledge systems, disciplines, and timelines different from their own background (Méndez et al., 2015). The

goal is to find a solution to a collectively defined problem, a PAR process can develop in practically any situation where researchers and non-researchers collaboratively conduct an investigation (Méndez et al., 2017).

What appears to direct the outcomes of a particular PAR process is a consequence of the attributes and beliefs that participants wield and apply to their specific context (Méndez et al., 2017, p. 3). Effective PAR agroecological processes incorporate the following essential principles: the establishment of trust, accountability, humility, active participation belief in collective action, and "a shared interest in research by partners" (Méndez et al., 2017, p. 1). Another vital component of the PAR processes is reflection, when conducted in a manner that is intentional and explicit.

Cross-generational collaborations are essential to obtaining long-term benefits (Méndez et al., 2017, p. 1). Furthermore, "PAR is a complex, negotiated process, where each partner articulates potential contributions, advocates for specific interests and names tangible benefits that they hope to obtain from the process" (Méndez et al., 2017, p. 3). When addressing traditional power disparities linked to gender, race, and socioeconomic status it is necessary for partners to establish noteworthy benefits of the research via ongoing negotiations, in order to help guide the success of the project (Méndez et al., 2017).

The PAR process utilizes agroecological principles as an effective method of highlighting the prowess of non-researchers, who hold "deep knowledge of place, content and practices" and become active collaborators with those formally trained in conducting research and experimental design (Méndez et al., 2017, p. 1). Hopefully, this

collaborative effort bears fruit of co-created knowledge that can be applied, i.e., "actionable" (Méndez et al., 2007, p. 1). As opposed to reductionist models, PAR showcases non-linear, "context-specific approaches" and "complexity thinking" (Méndez et al., 2017, p. 1).

The PAR approach outlined in this paper is rooted in the belief that research can find solutions to day-to-day local problems. In addition, this kind of research addresses "complex global issues" (Méndez et al., 2017, p. 2). As stated earlier, PAR assists in the ascertainment of "appropriate solutions (or at least reasonable responses) to real-life problems," by employing various "methodologies and with triangulation from multiple perspectives" (Méndez et al., 2017, p. 4). Finally, PAR processes are apt to be successful outcomes when led by the essential principals mentioned earlier (Méndez et al., 2017).

Food Sovereignty

Winona LaDuke said it best, “Food sovereignty is an affirmation of who we are as Indigenous peoples and a way, one of the most surefooted ways, to restore our relationship with the world around us” (Ligteringen, 2015, p. 1). With many food sovereignty definitions out there, 500 delegates from more than eighty countries met at the Forum for Food Sovereignty in Sélingué, Mali in 2007, proclaiming the Declaration of Nyéléni, which stated: “Food sovereignty is the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems…” (p. 3). Similarly, in The Indigenous Food System Network (2021) defined the term *Indigenous food system* as the following:

> [The] land, air, water, soil and culturally important plant, animal and fungi species that have sustained Indigenous peoples over thousands of years. All parts of Indigenous food systems are inseparable and ideally function in healthy interdependent relationships [and are] best described in ecological rather than neoclassical economic terms. [Indigenous foods] cultivated, taken care of, harvest, prepared, preserved. Indigenous food systems include all of the land, air, water, soil and culturally important plant, animal and fungi species that have sustained Indigenous peoples over thousands of years. All parts of Indigenous food systems are inseparable and ideally function in healthy interdependent relationships to transfer energy through the present day agriculture based economy that has been developed and industrialized through the process of colonization (p. 3).

Although the practice of food sovereignty is not a new concept, with food sovereignty being one of the continuous goals of Indigenous Nations since conquest, there exists a thriving and ever-blossoming contemporary food sovereignty movement. Robin and Cidro (2020) asserted that Indigenous food sovereignty places in context Indigenous Nations’ “commitment and connection” to their land and their relations,

needing to have “self-determination over the food we grow, harvest, hunt, fish, and gather” (p. 136). This imperative and thoughtful notion is widespread throughout Indigenous reservations and reserves (Robin & Cidro, 2020, p. 136).

Was it Really Wild?

Unfortunately, there lingers a calamitous concept in the collective consciousness — the pristine myth — the idea that within the Americas in 1492, the land was a wilderness devoid of human touch, inhabited by small populations of people (Denevan, 1992, p. 369). However, this is not true, for there existed enormous populations of peoples widespread throughout the Americas, an immense diversity of Indigenous Nations living within ingeniously human-engineered landscapes, reciprocally coevolved with plants, animals, and all other beings, physically and spiritually interwoven within the web of life and the holiness of nature (Denevan, 1992, p. 369).

The ancient Mexica of modern-day Mexico, long before European contact, for example, mobilized “hundreds of farmers, mathematicians, ‘diviners,’ landscape architects, and civil engineers among other specialists” of their twin-island metropolis “to design, construct, and repair and maintain structures like aqueducts and viaducts, terraces, check dams, dikes, canals, ponds” (Peña et al., 2017, p. 353). At the “lake district of Texcoco-Chalco-Xochimilco,” the Mexica constructed enormous hydraulic systems in combination with the incorporation of “ancient Maya xinampa agricultural techniques,” creating “floating gardens,” which abundantly produced corn, beans, squash, amaranth, fruits, poinsettias, gladiolas, “and thousands of herbs and medicinal plants” (Peña et al., 2017, pp. 353-354).

Peña et al. (2017) articulated how the US orchestrated slaughtering of bison also led to "displacement" and the destruction of the quilt, woven throughout the millennia, of "millions of acres of polyculture gardens and shifting agroforestry mosaics that stretched across entire bioregions of the Indigenous corn belt" (p. 347). Indigenous peoples utilizing permaculture principles transformed "Natural" environments into magnificent and enormous human-designed gardens (Peña et al., 2017, p. 347). Unfortunately, as Peña et al. (2017) explicitly elaborated, permaculture principles are hardly ever "recognized as having Indigenous origins," including:

> Perennial and annual polycultures, crop rotations with long duration fallows, intercropping with biodynamic and allelopathic companion plants, the classification and care of soils, the preparation and application of biodynamic soil treatment concoctions—all these and many more agroecological practices are results of Indigenous knowledge. (p. 348)

Peña et al. (2017) argued that there is strong evidence of revitalization of Traditional Ecological Knowledge and praxis via the endeavor for food sovereignty throughout the Americas, which is a portion of a broader "social movement to restore Indigenous territories and regenerate eroded lands, while revaluing our place-based agroecological knowledge" (p. 349). Likewise, Peña et al. asserted that the origin of "an agroecological revolution" (or better yet, an evolution) for a healthier future beyond the limitations of the settler colonial imagination is "digging up Indigenous soil knowledge" (p. 350).

Between 1248–1521 A.D. at Tenochtitlan-Tlatelolco, Mexica "scholar-farmers in the calmecacs ('line of houses,' referring to higher education institutions)" developed a sophisticated soil classification system, with more than sixty types of soil. The Mexica described the various soil types "in terms of variations in the ratio of organic to stony

material, depth of topsoil with recognition of distinct strata, permeability, erosive properties, compaction sensitivity, and color" (Peña et al., 2017, p. 350). Moreover, Mexica and Maya soil knowledge, a precursor of soil science, encompassed ample directions for proper human conduct given that certain actions could result in "uncertainty and unintended consequences" (Peña et al., 2017, p. 350). For example, if one's careless lead to overtilling of the incorrect soil profile, this could result in the formation of a compacted layer of clay, i.e., hardpan, referred to as "Tepetate" by the Mexica scholar-farmers (Peña et al., 2017, p. 350). Therefore, Mexica and other "Indigenous soil vernaculars" indicate that Indigenous knowledge of soil is interlinked to "instruction in land-care ethics" (Mihesuah & Hoover, 2019, p. 328).

Devon Peña explained that there is an abundance of evidence illuminating the prominence of the intertwined "fields of Indigenous knowledge of ethnoedaphology (Indigenous models of ecosystem processes in soil), ethnopedology (Indigenous classifications of soils), and ethnobotany," in which he defined as "Indigenous knowledge of the soil biodynamic, nutritional, and medicinal properties of plants" (Mihesuah & Hoover, 2019, p. 325). This trinity of scientific disciplines is the embodiment of Traditional Ecological Knowledge (TEK) (Indigenous knowledge/praxis) of the synergetic and symbiotic relationships between polyculture, companion planting, and soil quality/fertility, i.e., soil TEK (Mihesuah & Hoover, 2019, p. 325).

Following the brutal entrance of Spanish conquistadors into what is today Mexico, "and the unfolding of a veritable ecological and cultural apocalypse," Catholic Franciscan friars conducted an ethnography project; they enlisted "Native scholars who

were often described as ‘unworthy servants’” to co-produce manuscripts comprised of “Mexica (Aztec) glyphs, numerology, and related symbolic forms alongside Latinized Nahuatl,” Latin narratives/nomenclature, and archaic Castilian in an attempt to preserve Indigenous knowledge of native plants’ medicinal properties (Mihesuah & Hoover, 2019, p. 325).

Interestingly, many of these exact medicinal native plants are essential companion plants cultivated within “polyculture milpa” — i.e., corn, bean, and squash agroecosystems — given medicinal native plants dualistic nature and value of being both “medicine for the body and the land (soil) and other plants that co-inhabit the agroecological landscapes in biochemical feedback loops” (Table 1) (Mihesuah & Hoover, 2019, pp. 325-326). Unfortunately, and not surprisingly, “colonial manuscripts, and indeed most discourse in the biodynamic and permaculture movements,” fail to observe Indigenous companion plants’ duplexity, beneficially serving ethnobotanical and biodynamic purposes (Mihesuah & Hoover, 2019, pp. 325-326). For example, within the colonial manuscripts in a drawing alongside notes that described how “atzitzicaztli (*Urtica chichicaztli*)” commonly called water nettle, was prepared by taking “the juice of nettle, ground with salt and mixed with urine and milk, can be poured into the nostrils to stanch a nosebleed” (Mihesuah & Hoover, 2019, p. 326). However, within the manuscripts, the plant’s diverse biodynamic properties are not discussed (Mihesuah & Hoover, 2019).

Building from the ancient and ancestral foundational understanding of Indigenous soil TEK, that medicinal plants are both medicine for the human body and the earth body,

water nettle, “atzitzicaztli,” is revered and utilized by Indigenous campesinos (farmers) “to promote the formation of humus in the soil” (Mihesuah & Hoover, 2019, p. 327). Additionally, there exists evidence that when Atzitzicaztli (water nettle) is grown along with “corn-bean-squash intercropping, it suppresses bindweed” (Table 1) (Mihesuah & Hoover, 2019, p. 327).

Table 1. Ethnomedical and biodynamic/agroecological properties of select companion plants in traditional milpas (Mihesuah & Hoover, 2019, p. 331).

Plant	Ethnomedical Values[a]	Soil Biodynamic/ Agroecological Propwerties[b]
Chamomile[c] *Manzanilla (Chamaemelum nobile)*	Tea has calming effect; sulfur content has antifungal properties; hay fever relief; anti-inflammatory; combats muscle spasms, menstrual disorders, insomnia, ulcers, wounds, gastrointestinal disorders; prevents rheumatic pain; reduces swelling of hemorrhoids.	Roots loosen compacted earth so that other plants can find nutrients and water. Preparation of flower "tea" helps unblock plant sap and prevents stress from excess heat/cold; adds sulfur and calcium to compost mixes; high in potassium. Stabilizes nitrogen within compost and increases soil life to stimulate plant growth.
Datura *Tolohua (Datura innoxia)*	Analgesic; narcotic effects used in setting broken bones, making incisions, and relieving painful bruises and other injuries. Anti-angiogenesis properties.	Leaf hexane extract has insecticidal potential. Facilitates phytoextraction of heavy metals from soil (e.g., excess cadmium, chromium). Grows in alkaline soils. Should not be grown alongside potato plants, as it can be a center of viral infections.
Lamb's quarters *Quelite (Chenopodium album)*	Astringent; upset stomach relief; prevents scurvy. Tea used to treat diarrhea.	Is useful as "trap crop" for leaf miners. Hosts beet leaf hopper. Restores healthy nutrients to the soil (except that phosphorous may not be bioavailable to plants for many years through green manure).
Laurel; Mexican bay leaf *Eca-patli (Litsea glaucescens)*	Bruised together in frigid water with other herbs and stones, then soaked in a neck wrap, it can relieve sore throats and head and neck pains.	Creates a supportive microclimate for shade-tolerant pulses and vegetables.

Table 1 Continued. Source: Plants listed in the Martín de la Cruz-Badiano Codex of 1552 (Mihesuah & Hoover, 2019, p. 332).

Plant	Ethnomedical Values[a]	Soil Biodynamic/ Agroecological Propwerties[b]
Marigold *Yauhtli* *(Tagetes lemmonii)*	Ointment can be used to soothe sunburns, warts, bites, acne, and ulcerations; and to heal wounds, dry skin, and blisters.	Protects other plants by releasing a chemical that deters potentially lethal root-infesting nematodes. Chemical also reduces chances of fungal, bacterial, viral, and insect problems; attracts beneficial insects.
Papalo *Papaloquelite* *(Porophyllum ruderale)*	Soothes coughs, headaches; reduces flatulence after consuming legumes (beans, lentils).	Cold-hardiness contributes to protective cover and supports soil moisture, prevents hardpan, and attracts beneficial insects.
Purslane *Verdolagas* *(Portulaca oleracea)*	Leaves are rubbed on insect or snake bites; soothes boils, sores, pain from beestings; contains more omega-3 fatty acids than any other leafy plant; high in vitamins A, C, E, and B.	Creates humid microclimate for nearby plants; deep roots can bring up moisture and nutrients other shallow-rooted plants (e.g., corn) cannot reach.
Water nettle *Atzitzicaztli* *(Urtica chichicaztli; U. dioica)*	Ground with salt and mixed with urine and milk to stanch bleeding.	Promotes formation of humus in soil; suppresses bindweed; can be sprayed on sick or stressed plants as liquid manure.
Yarrow *Tlalquequetzal* *(Achillea millefolium cv.)*	Flowers and leaves are eaten or made into a tea-like drink; fresh leaves are applied to stanch bleeding wounds; treats gastrointestinal problems and fevers (infections); lessens menstrual bleeding; promotes circulation.	Preparation enhances crops' ability to absorb potassium in a balanced manner. Enables soil to absorb and retain silicic acid. Aids in the formation of quality plant proteins.

Contemporary Indigenous Soil Traditional Ecological Knowledge

Devon Peña highlighted that in Michoacán, Mexico there is a contemporary manifestation of Indigenous soil TEK within P'urhépecha farmers' "soil classification–farming–ceremonial complex" and argued that the P'urhépecha soil model is several hundred years ahead of modern soil science (Mihesuah & Hoover, 2019, p. 329). Differing to that of land-grant university research, contemporary P'urhépecha's communal soil classification practices embody the incorporation of education and "practical activities linked to collective and communal work organizations that are traditionally responsible for protecting and improving soil quality" (Mihesuah & Hoover, 2019, p. 330). Likewise, soil health/fertility is "common property relations and moral obligations," where soil TEK and other aspects of TEK, such as Indigenous agroforestry, knowledge/skills are shared in accordance with "ceremonial and agricultural calendar cycles" (Mihesuah & Hoover, 2019, p. 330).

Inspired Methodologies

Many studies have found that social interaction is imperative in online learning environments. For instance, "the quality and quantity of interactions are important to students' satisfaction in online courses" (He et al., 2019, p. 102). Additionally, collaborative learning theory emphasizes that students interacting with peers can expand their knowledge (He et al., 2019, p. 102). This specific study on online information technology (IT) education illustrates the vital role of facilitation for online learners' successes and recommends that instructors act as leaders, sparking discussion to promote

"higher levels of thinking and knowledge construction" (He et al., 2019, p. 103). In order to reach these aims, the authors argued that online instructors must structure this interaction, i.e., discussion, while simultaneously guiding students in the development of their critical thinking capabilities.

He et al. (2019) emphasized that standard online discussions are apt to have long threads, which differs from that of anchored asynchronous online discussions where students make "reference points" between comments by creating new discussion threads, thus constructing a focus (He et al., 2019, p. 103). Other studies reveal "anchored asynchronous online discussions were more likely to help increase students' self-efficacy than standard online discussions" (He et al., 2019, p. 103). Online technological innovations, e.g., asynchronous discussions, when complemented by pedagogical scaffolding, promote effective teaching and learning, especially when students are engaged in "real-world activities to learn key concepts" (He et al., 2019, p. 103).

Dunaway and McCarthy (2015) highlighted the "lessons learned" in a Case Study when Quinnipiac University School launched an online graduate business analytics Bachelor of Arts program (p. 152). More specifically, as a result of their experiences Dunaway and McCarthy learned the essentialness of having faculty utilize best practices of online pedagogy, where instructors do not need to "re-invent the wheel," but need to "begin with the end in mind" (p. 155). In other words, in the development of an interdisciplinary program, first define the learning outcomes and determine the target audience (p. 154).

Dunaway and McCarthy (2015) analyzed and developed the "lessons learned" from their experiences in launching an online business analytics program. In particular, they recognized the importance of faculty "utilizing best practices for on-line pedagogy," while students learn from their mistakes and apply course content to problem-solving (p. 155). To foster strong student participation and positive online course outcomes Palloff and Pratt (2001) argued that "excellent" online course development and delivery are necessary to achieve these goals (p.xiii). To develop effective online courses, Palloff and Pratt (2001) suggested those interested in successful online instruction to become their "own trainer-developers" (p. xiii).

Schroeder-Moreno (2010) conducted a study which analyzed student feedback and evaluations collected throughout eight semesters from an introductory agroecology online course at North Carolina State University. The results from the study indicated that in order for successful construction and instruction of an online course, there must be clear expectations, guidance, and frequent/constructive instructor feedback (Schroeder-Moreno, 2010, pp. 29-30). Furthermore, this study determined that within a successful online learning environment, "online students need to feel that they are part of an interactive and collaborative learning community" (Schroeder-Moreno, 2010, p. 30).

Building from Palloff and Pratt's (2001) salient point that "excellent" online course development creates student engagement, it becomes crucial to understand what is needed to construct an effective course structure. One helpful structure is dividing and sharing the course content throughout a number of phases. Phase one of an online course, also known as the "course beginnings" is a great opportunity for enrolled students to

become comfortable using the online platform, share their personal backgrounds, and understand the syllabus (Boettcher & Conrad, 2016, p. 10). The online facilitator's role during the "course beginnings" is to make course expectations clearly understood, establish a social presence, all the while familiarizing oneself with students' backgrounds (Boettcher & Conrad, 2016, p. 10).

In the first phase of a course, it is necessary for students to have access to required resources, in addition to supplemental content resources (Boettcher & Conrad, 2016, p. 10). Moreover, in the first phase, "tools for the designed learning experiences are in place, and learners know how to use them" (Boettcher & Conrad, 2016, p. 10). During the "first phase of a course, the goals are to launch the course well, laying the groundwork for a learning community in which learners and faculty support one and another in the accomplishment of course goals" (Boettcher & Conrad, 2016, p. 10). It is necessary to explicitly state the course goals and/or learning objectives.

Learning objectives articulate what students will learn by participating in an education/training session These objectives must be chosen deliberately, because by design, "they set the tone and direction for what participants are expected to do and learn during the instructional activity or the instructional unit" (Caffarella & Daffron, 2013, p. 182). When designing online instruction, in addition to the learning outcomes, it is vital to have students focus on "acquiring knowledge; enhancing cognitive skills; developing psychomotor skills; strengthening problem-solving and problem-finding capabilities; and changing feelings, beliefs, or values" (Caffarella & Daffron, 2013, p. 182).

Additionally, learning objectives impart a focus and orderliness in the overarching design of instruction. Learning outcomes provide parameters for deciding course content, teaching strategies, and formative assessment techniques (Caffarella & Daffron, 2013, p. 182). Lastly, to decide on course content, (Caffarella & Daffron, 2013) suggest to simply ask what content is essential for learners to understand and does this content address the learning objectives?

Let us return to the idea that course success is often dependent on a sequential design, i.e., phases of a course. In the second phase, the paramount objective besides the continued development of the learning community is for the student to become enthralled with the course content, thus establishing the foundation for higher-level learning and course projects towards the end of the course (Boettcher & Conrad, 2016, p. 10). While at the same time during phase two, the online facilitator maintains a strong teaching presence, supporting the community, and guiding students to learn the core concepts (Boettcher & Conrad, 2016, p. 11). Boettcher and Conrad (2016) elaborated further in the second phase students develop a weekly rhythm of engaging with course concepts, readings, and participating in the course community through discussion posts (p. 11).

Collison et al. (2000) argued that one of the ways to cultivate this dynamic and engaging online learning is using asynchronous online discussions, i.e., text-based conversation not occurring in real-time. Asynchronous online discussions give students and facilitators significant advantages compared to the traditional face-to-face learning environment. For example, “extended reflection time” often leads to well-thought-out written responses, deepening conversation and learning between course participants.

There are several published studies about "appropriate 'netiquette' (Internet etiquette) and successful strategies for facilitating constructive online discussion" (p. xv). These studies stress significance in facilitating "goal-driven environments," i.e., online courses, be as adept (as possible) in cultivating meaningful online dialogue (pp. xv-xvi). Many educators have given high praise to the added value and advantages created by using (asynchronous) text-based discussion. Quality discussion results from hard work, persistence, and skill of an effective moderator. Furthermore, "online moderation is a craft that has general principles and strategies" (p. xviii).

Collison et al. (2000) elaborated on one essential style to be an effective moderator of a virtual learning community is conducting oneself using the "Guide by the Side vs. Sage on the Stage" (p. xviii). A facilitator utilizing this style encourages "pragmatic dialogue" to develop a "productive focus," guiding the virtual community in order to achieve course objectives (p. xviii). Ultimately, the "Guide by the Side" style allows an online instructor to "offer diagnosis of what a discussion might need to move forward," in order to stich the conversation and concepts together (p. xviii). Collison et al (2000) expressed this idea in the following way:

> [There is a] wide palette of voices and tones that a professor, teacher, trainer, or online moderator can use to focus and move a discussion forward. Knowledgeable use of such strategies can enrich and deepen the dialogue and foster learning in this emerging venue. (p. xv)

In phase three, students focus on course concepts and apply core concepts in particular case studies, scenarios, and complex problems (Boettcher & Conrad, 2016, p. 11). The facilitator's role in the third phase shifts time from large group presence to more personalized and small groups teaching presence. Boettcher & Conrad (2016) referred to

the fourth and final phase of a course as “Pruning, Reflecting, and Wrapping Up” (p. 11). During this last phase of a course, the primary goals for the learner are to complete a “positive learning experience,” where they reflect and digest the skills and knowledge, they have cultivated from participating in the course (Boettcher & Conrad, 2016, pp. 11-12). Lastly, the facilitator supports students’ wrap-up (reflection) assessment activities and provides feedback (Boettcher & Conrad, 2016, p. 12).

According to Boettcher and Conrad (2016) concept mapping is an excellent choice for wrapping up a course (p. 230). Concept mapping is wonderful tool, especially when considering what you want the students to take from the course, such as the essential course concepts (Boettcher & Conrad, 2016). Concept maps are graphic organizers (diagrams) that exhibit students’ mental connections between significant concepts, i.e., a “conceptual schemata,” which is the “patterns of association” students create in correlation to a specific “focal concept” (Angelo & Cross, 1993, p. 157). The physical and visual act of drawing connections between concepts, one acquires more command over major focus points/themes. While constructing a concept map, one is capable of organizing, developing, and synthesizing ideas.

The purpose of a concept map is tap into one’s unique creative potential to develop and guide their ideas, through a process of “distilling,” one transforms concepts into new ideas, where a synthesis of ideas happens. Concept mapping is a valuable tool generally considered for various “types of cognitive process,” including the integration of knowledge, assessment of learning, identification of misconceptions, problem-solving,

and brainstorming" (Boettcher & Conrad, 2016, p. 230). Novak and Cañas (2008) defined concept maps as the following:

> Graphical tools for organizing and representing knowledge. They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts. Words on the line, referred to as linking words or linking phrases, specify the relationship between the two concepts (p. 1).

As stated earlier, concept maps can be an effective tool for assessing students' knowledge before or after a learning activity (Novak & Cañas, 2008). For a better understanding, see Novak and Cañas' following meta graphical representation of a concept map:

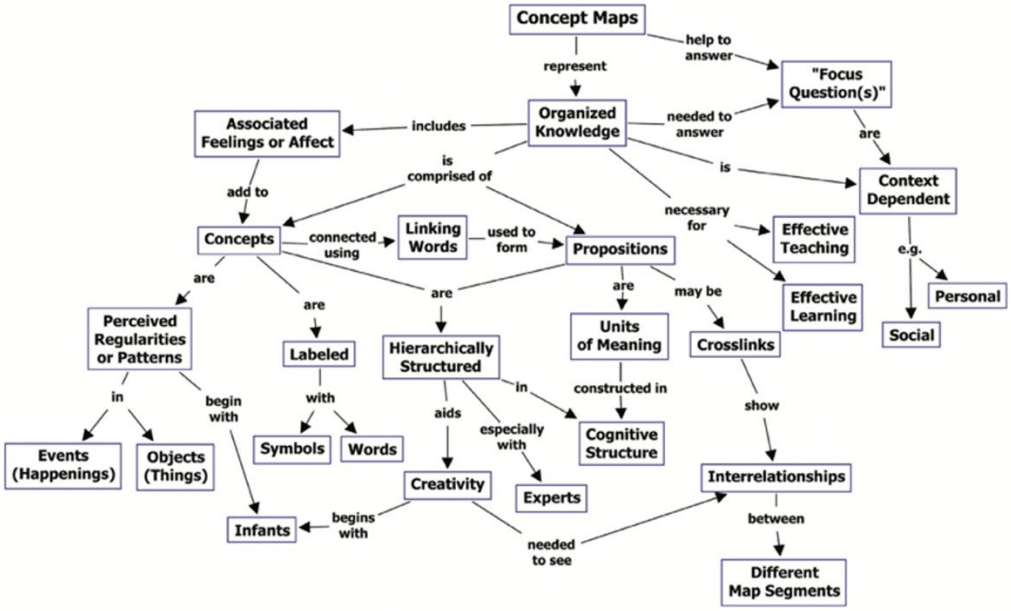


Figure 1. A concept map showing the key features of concept maps. Concept maps tend to be read progressing from the top downward.

Figure 2. Meta graphical representation of a concept map (Novak & Cañas, 2008, p. 2).

Indigenous Research Methodology

First and foremost, the term Indigenous refers to people that are the original inhabitants of the world or who identify their ancestry to these original peoples (Wilson,

2008, p. 34). The term Indigenous with a capitalized “I” has become politically charged as Indigenous people assert their "collective rights as self-determining peoples" at the international level (Wilson, 2008, p. 34). Wilson (2008) alluded to the idea that Indigenous cultural ceremonies are properly prepared so that all participants are able to go “beyond the everyday” to experience and “accept a raised state of consciousness” (p. 69). Therefore, Indigenous scholars make the parallel that “research is a ceremony” (Wilson, 2008, p. 69).

Indigenous scholars have articulated what comprises an Indigenous research paradigm and demand that research conducted within Indigenous communities follows the specific Indigenous Nation’s codes of conduct, while honoring their “systems of knowledge and worldviews” (Wilson, 2008, p. 8). To understand an Indigenous research paradigm, we must build our conceptual framework that a research paradigm is comprised of the following four entities: ontology, epistemology, axiology, and methodology.

Indigenous Ontology & Indigenous Epistemology

A research paradigm is the implicit beliefs, biases, or underlying assumptions that pilot the actions taken by a researcher (Wilson, 2008, p. 13). More specifically, one’s way of being is rooted in their ontological perspective, with ontology being a theory or belief of the very nature of reality. How one knows or thinks their reality, i.e., one’s ontology (worldview), is via epistemology (Wilson, 2008, p. 13). An Indigenous epistemology put simply is the development of ideas through the process of fostering

relationships. In other words, “An idea cannot be taken out of this relational context and still maintain its shape” (Wilson, 2008, p. 8).

Both an Indigenous ontology and Indigenous epistemology are formed by and informed by relationships. Therefore, many Indigenous peoples live by, think about, and know reality through relationality, i.e., the state of being connected via relationships. Cajete (2000) beautifully articulates Indigenous relationality in the following way:

> The psychology and spiritual qualities of Indigenous people’s behavior reflected in symbolism were thoroughly ‘in-formed’ by the depth and power of their participation mystique with the Earth as a living soul. It was from this orientation that Indian people developed ‘responsibilities’ to the land and all living things, similar to those that they had to each other. In the Native mind, spirit and matter were not separate; they were one and the same (p. 186).

Similarly, Wilson (2008), speaking on behalf of his Cree Indigenous culture, stated, “Our reality, our ontology is the relationships,” i.e., a web of relationships woven into a perception of reality (p. 76). Thus, an Indigenous paradigm is derived from “the foundational belief that knowledge is relational (Wilson, 2008, p. 74). The concept of relational knowledge is that knowledge is not just interpersonal, but is a relationship shared with all of creation, the cosmos, the plants, the animals, the earth (Wilson, 2001, pp. 91-92).

To highlight this idea that knowledge is relational, objects are not named in the Cree language; instead, the function of the object is what is spoken (Wilson, 2008, p. 73). Take for example the English word for pen in Cree is “something that you write with” (Wilson, 2008, p. 73). The pen is not what is important, but your relationship to it, and in this case, its usefulness. “Native languages are verb based… In a sense, language

‘choreographs’ and/or facilitates the continual orientation of Native thought and perception toward active participation, active imagination, and active engagement with all that makes up natural reality,” a web of relationships (Cajete, 2000, p. 27).

Indigenous Axiology

Axiology is the study of the nature of value, the ethics that direct the pursuit of knowledge, while congruently appraising what is worth researching (Wilson, 2008, p. 13). An Indigenous axiology is constructed from the conceptual framework of “relational accountability,” in other words, being accountable to your relationships (Wilson, 2008, p. 77). Therefore, an Indigenous research paradigm by its very nature is relational, thus sustains relational accountability (Wilson, 2008, p. 71).

Furthermore, in terms of applied Indigenous research, this relational accountability has meaning when a research relationship's role and associated responsibilities are properly fulfilled. The researcher is “a part of his or her research and inseparable from the subject of that research” (Wilson, 2008, p. 77). Additionally, the knowledge procured and interpreted must be respectful of the relationships that were created during the research process (Wilson, 2008, p. 77). Likewise, this acquired knowledge (research) must contribute to further growing these relationships. Lastly, the paramount ethical actions and considerations when deliberating on the approaches of applying Indigenous research methods (IRMs) are the development of relationships and the location of the research (Windchief, & San Pedro, 2019, p. xv).

Indigenous Research Methodology

A methodology is the theory of how knowledge is acquired or the science of figuring things out (Wilson, 2008, p. 34). An Indigenous researcher or a non-Indigenous person employing an Indigenous research methodology has "a vested interest in the integrity of the methodology" and acting out of reciprocity, realizes the usefulness of the researcher's results to the Indigenous community (Wilson, 2008, p. 77). An Indigenous research methodology embodies reciprocity, respect, and responsibility (Wilson, 2008, p. 77).

Building from our conceptual framework that an Indigenous research paradigm is comprised of ontology, epistemology, axiology, and methodology, Wilson (2008) utilizes the iconic Indigenous medicine wheel symbol (Figure 1). In general, an Indigenous medicine wheel symbol is a circle with distinct colorful quadrants representing the four directions and much more, as analogous to that of the Indigenous research paradigm (p. 70). Wilson's analogy illustrates that similar to the four colors of the medicine wheel, the ontology, epistemology, axiology, and methodology of the Indigenous research paradigm are interdependent, integral, and inextricable (Figure 2) (p. 70).

Figure 3. Medicine wheel from the Michi Saagiig Anishnaabeg Nation. Photo Credit: <http://www.curvelakeculturalcentre.ca/culture/medicine-wheel/>

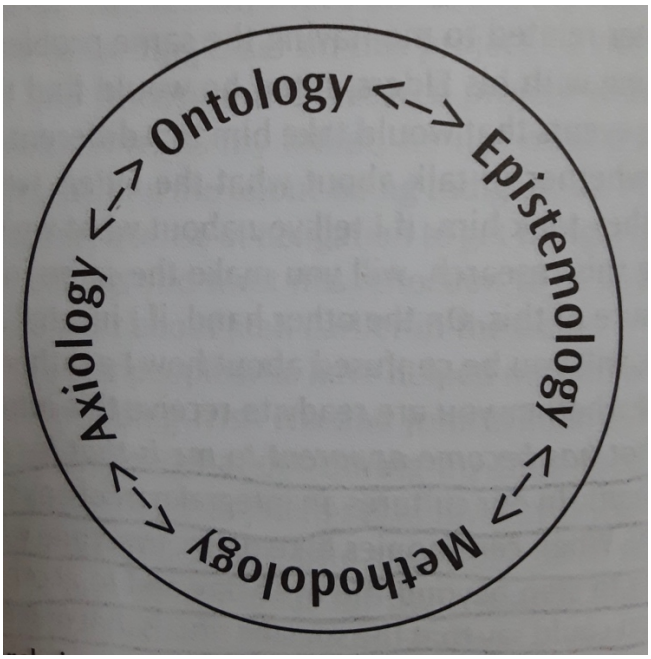


Figure 4. Indigenous research paradigm (Wilson, 2008, p. 70).

Similar to the medicine wheel in Figure 3, the circle in Figure 4, all components are equivalent, affecting one another, and cannot exist without the other (Wilson, 2008, p. 70). Harmony between research methods and Indigenous paradigms "requires a

significant level of reflexivity to understand our relationships with those who invite us to learn with them" (Windchief & San Pedro, 2019, p. xv).

Literature Review Conclusion

Conducting this literature review has considerably empowered me to understand better how one can design and effectively carry out an online curriculum. More specifically, as a result of this research, I now have a solid conceptual foundation that was significantly informed for my MSSE capstone project and enabled me to implement my agroecology curriculum successfully. Diving deep into a handful of excellent sources on the needed qualities and techniques for effective online facilitation has gifted me many essential tricks of the trade.

Through these books and articles, I learned the value of having students make meaning of the scientific concepts by applying this information to their local environment. The students who participated in my capstone project applied course knowledge and skills by designing individual PAR projects.

In summary, if designed correctly in sequential modules and facilitated in an engaging and gentle way, online learning environments can be significantly meaningful for students and instructors. Fostering an online community is vital, creating a safe space for students to independently learn and learn from their peers. By following best practices in online course design and facilitation, one can create the conditions conducive for effective student learning.

With the acquired grasp of what composes an Indigenous research methodology, I integrated this knowledge and applied it during my student interviews by first developing

respectful and reciprocal relationships. I developed respectful relationships by conducting myself with integrity. I created reciprocal relationships by sharing my research study's results with the Blackfeet Community and collaborating with them in determining the best way to do this. Additionally, I incorporated an inclusive openness to the Blackfeet ontology and epistemology in order to conduct my research in a responsible manner. I did this by teaching/sharing the food sovereignty work currently going on within Blackfeet Nation.

In October 2020, I met with the Food Policy Planner of the Blackfeet Agricultural Resource Management Plan (ARMP) and discussed their food sovereignty work, which I integrate into my curriculum. I am grateful to have had this excellent opportunity to learn about and be inspired by the Indigenous research methodology model. I feel like this information is something I now embody, and it greatly informed my study, i.e., engaging in reciprocity, being respectful, responsible, and accountable to my prior students, the Blackfeet Community College, and the Blackfeet Nation.

A reflection feedback tool that I used throughout my action research process was asking myself Weber-Pillwax (2001)'s following questions:

> How do my methods help to build respectful relationships between the topic I am studying and myself as [a] researcher (on multiple levels)? How do my methods help to build respectful relationships between myself and the other research participants? What is my role as a researcher in this relationship, and what are my responsibilities? Am I being responsible in fulfilling my role and obligations to the other participants, to the topic and to all of my relationships? What am I contributing or giving back to the relationship[s]? Is this sharing, growth and learning that is taking place reciprocal? (p. 77).

METHODOLOGY

Demographics

Course participants signed proper documentation, consenting to participate in a post course questionnaire and a post course student interview. My close Blackfeet friends connected me to staff at Blackfeet Community College (BCC) who were willing to collaborate and allow me to teach my course to BCC students and staff. The BCC student and staff member that worked with me were also completing internships with USDA Extension Agency at BCC.

As a requirement of the USDA internship, USDA interns needed to create a personal project to improve the Blackfeet Community College Farm and/or the Blackfeet Nation at large. Therefore, my course design of incorporating participatory action research (PAR) projects served to develop student-intern required projects. As mentioned above, I taught my course to two participants actively involved in the six week-long unit. Course participants signed proper documentation, consented to participate in a post-course questionnaire, and post-course student interviews. Initially, this study started out with a sample population of four. However, due to life circumstances two students decided not to be USDA interns nor participate in this study.

Treatment

Previously stated, for my capstone project I constructed and tested an online natural science curriculum. More specifically, I tested an online curriculum focused on the science of agroecology, native food systems, and food sovereignty. Leading

academics in the field of agroecology such as Gliessman, Méndez, Bacon, and Cohen (2017) defined agroecology as "an approach that seeks to integrate ecological science with other academic disciplines (e.g., agronomy, sociology, history, etc.) and knowledge systems (e.g., local, indigenous, etc.) to guide research and actions towards the sustainable transformation of our current agrifood system" (p. 1). The action research for my MSSE capstone project intended to effectively engage students through an online science curriculum scaffold in sequential modules, interwoven with meaningful online discussion, and facilitated in a gentle way. Through a partnership the Blackfeet Community College (BCC), I facilitated a six week-long agroecology and regenerative food systems online course with one BCC college student and one BCC staff member.

My science curriculum implemented a multi-media method of utilizing books, articles, videos, audio lectures, and Blackfeet guest speakers, to convey scientific thoughts and the "how-to" of applying core course concepts information to unique local environments. Specifically, I scaffolded key course concepts in sequential online modules (Appendix E), which built into a final summative course project. To achieve the goal of transforming theory into praxis, my capstone study participants took course knowledge and skills and implemented them into action via the design and implementation of individual participatory action research (PAR) projects. PAR aims to conduct research that applies to the local context, i.e., solving local problems. Moreover, the PAR approach involves a diversity of participants engaged in "cyclical, iterative process that integrates research, reflection, and action" (Méndez et al., 2015, p. 5).

Participants of my treatment created PAR projects that grounded scientific concepts gleaned from the science of agroecology and other fields of knowledge to enhance and/or heal their respective local environment. Concept mapping served to develop student PAR projects (Appendix A). Given that within a PAR project, local environment contexts are never devoid of community issues, JC, a BCC college student/study participant elected for his PAR Project the planning of Missing and Murdered Indigenous People (MMIP) event to bring about community awareness and foster support systems throughout the Blackfeet Nation. To learn more about MMIP, please visit the following website: dojmt.gov/mmip-home/

My other study participant, Teri, chose to implement course knowledge of agroecology and agroforestry into her PAR Project plan. More specifically, for the 2021 growing season Teri will be growing a pumpkin patch for cultural activities utilizing course knowledge of intercropping, companion planting, and multi-story trophic levels within her agroecosystem design.

Instrumentation of Treatment

In summer of 2020, during MSU's Foundations of Online Teaching Course, I designed the first two weeks of my six week-long science course and completed the remaining four weeks during MSU's Advance Online course in the Fall of 2020. In Spring 2021, I facilitated my Brightspace (D2L) course, during which, I utilized a mixed methods research approach composed of both quantitative and qualitative research techniques to answer my central Action Research Question of what are the outcomes of designing and teaching innovative online science curriculum? Please see the Research

Matrix on the following page, highlighting my research questions and the associated research method employed to obtain respective answers.

Table 2. Mixed method research matrix.

		Qualitative Research Methods	**Qualitative Research Method**
Focus Research Question	What are the outcomes of designing and teaching innovative online science curriculum?	**Student Interviews** provided me with direct feedback, assessing the degree of course effectiveness, in terms of my facilitation, course concept digestibility, and real-life relevancy.	**Questionnaires** assessed student's opinions and beliefs about my online science curriculum.
Sub Research Question	To what degree do students understand the science concepts taught?	**Student Interviews** allowed me to assess digestibility of course concepts and their applicability to students' respective local context.	**Questionnaires** gathered students' self-assessment of how well they understood essential course concepts.
Sub Research Question	What are student attitudes towards this unit?	**Student Interviews:** With the appropriate questions, student interviews clearly expressed student attitudes towards the treatment's online science course.	**Questionnaires** gaged the range of student attitudes towards the science course.
Sub Research Question	In what ways has this impacted me as a teacher?	**Student Interviews** helped me understand what I did well as an educator and what areas I can improve in.	

Data Collection and Analysis Strategies

As stated earlier, In Spring 2021, I facilitated my online science course titled "Food Sovereignty, Native Food Systems, and Agroecology" to two students. Throughout the course, I utilized a mixed methods research approach, comprised of quantitative and qualitative research techniques to answer my central Action Research Question of "What are the outcomes of designing and teaching innovative online science curriculum?"

Questionnaires

My quantitative research method of Questionnaires — created, managed, and emailed via Google Forums — provided an easy way to obtain completed student Questionnaires. Google Forums user-friendly interface allowed me to graphically analyze and interpret the data. My online questionnaire answers consisted of range of numbers valuing in degree of agreement towards a specific question, multiple choice answers, and open-ended responses; thus, making it easy to quantitively organize and analyze the results. I am grateful for Google Forums user-friendly program, which enabled be to easily create custom questionnaires.

I analyzed my data objectively and thoroughly, observing trends and outliners. Following this, I reflected on the possible causes of these trends and outliners. First, I deliberated and decided the science concepts I deemed essential for my students' understanding — agroecology, intercropping, agroforestry. Secondly, I crosschecked these essential science concepts with the concepts revealed in my students'

questionnaires and student interviews to determine the depth of student understanding of the science concepts taught. Additionally, questionnaires and student interviews reflected students' attitudes towards course design and my facilitation style/effectiveness for student learning.

Student Interviews

My qualitative research methods of administering student interviews to answer my research questions provided a direct collection method to answer my main action research question of "What are the outcomes of designing and teaching innovative online science curriculum?" I conducted student interviews during the final week of the course to obtain direct feedback from the two-student sampling size. My qualitative research approach of utilizing student interviews produced a rich dataset of genuine student perspectives on the course's effectiveness; for example, one student said, "the course's design has helped my overall understanding of the science of agroforestry." Moreover, administering student interviews aided me in assessing the degree of course effectiveness, in terms of my facilitation style, digestibility of course concepts, and real-life relevancy for students.

In particular, to answer my sub research question of "To what degree do students understand the science concepts taught?", the student interviews allowed me to assess the digestibility of the course concepts and their applicability to students' respective local context (Appendix B). Likewise, to answer my sub research question of "What are student attitudes towards this unit?" the appropriately crafted questions contained within the student interviews exhibited student attitudes towards the design of the online science

course and my effectiveness as an educator, and my teaching style (Appendix B). Lastly, student interviews effectively addressed my sub research question of "In what ways has this impacted me as a teacher?" and granted me a clear understanding of what I did well as an educator and what areas I need to improve in (See Data Analysis and Appendix B).

My plan for data analysis was a straightforward path once I collected my data. After appropriate deliberation, I reached meaningful conclusions from the data collected, and electronically stored all data and insights from the analyzed data, looking for themes and placing them in categories. Data analysis for my two student interviews began once I finished the time consuming albeit vital process of transcribing the recorded interviews.

Subsequently, I carried out the process of organizing and analyzing the noticed patterns and outliers of students' attitudes and understandings of the science course content, while simultaneously assessing my level of capability as a facilitator. Additionally, I searched for and selected quotes that depicted students' overall feelings and thoughts about my course. Once I reached meaningful conclusions from the data collected, I electronically stored all data and insights from the analyzed data for future use.

Triangulation

To safeguard my action research and make certain my research instruments had reliability and validity, I used the process of triangulation. Triangulation is the practice of correlating a diversity of data sources to demonstrate the validity of the facts presented "while trying to account for their inherent biases" (Mertler, 2020, p. 13). Therefore, during the implementation of my mixed methods research design, my qualitative and

quantitative data sets were simultaneously analyzed and compared (Mertler, 2020, p. 108). This process of triangulation revealed similar results between the qualitative and quantitative data; thus, giving my findings a higher level of credibility (Mertler, 2020, p. 108). Furthermore, in the Fall of 2020, during my Implementing "Action Research in Science Education" course at Montana State University, both my peers and professor showed approval of my study's research instruments aims of providing valid data via triangulation. Lastly, the Montana State University's Institutional Review Board granted the research methodology an exemption (Appendix C).

DATA ANALYSIS

Mixed Methods Research Approach

My action research was conducted employing a mixed methods research approach collecting data in order to answer my central action research question: What are the outcomes of designing and teaching an innovative online science curriculum? My sub research questions are as follows:

- To what degree do students understand the science concepts taught?
- What are the attitudes of participating students towards this online science course?
- In what ways has this impacted me as a teacher?

Questionnaires

For the quantitative research portion of this study, questionnaires were used. The questionnaires assessed student's opinions and beliefs about my online science course, as well as collected the students' self-assessment of how well they understood essential course concepts.

Student Interviews

This study also employed the qualitative research method of conducting student interviews. Student interviews allowed me to assess digestibility of course concepts and their applicability to students' respective local context. Additionally, student interviews provided me with direct feedback, assessing the degree of course effectiveness, in terms

of my facilitation, course design, and real-life relevancy. Student interviews clearly expressed student attitudes towards the science course. Lastly, student interviews helped me understanding what I did well as an educator and what areas I can improve in, illuminating how this experience of designing and teaching this course impacted me as a teacher.

Study's Sample

Two Blackfeet Community College (BCC) students took my online course, which I facilitated. The BCC students that worked with me were also completing an internship with USDA Extension Agency at BCC. As a requirement of the USDA internship students needed to create personal project to improve the Blackfeet Community College Farm and/or the Blackfeet Nation at large. Therefore, my course design of incorporating participatory action research (PAR) projects served to develop student-intern required projects. As mentioned above, I taught to two course participants actively involved in the six week-long online science course.

Timeline

In last week of April 2021, during the final week of instruction, Questionnaires were administered, and Student Interviews were conducted.

Results

Questionnaires

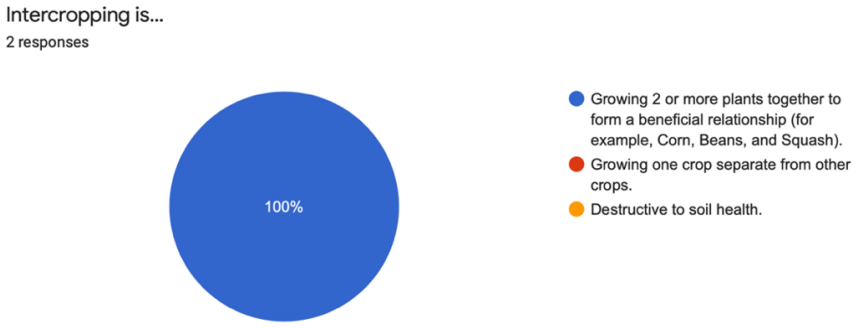
Table 3. Questionnaire results of student attitudes towards the science course.

Questionnaire Questions	N Sample Size	M Median
This course increased my knowledge. Scale (1=Strongly Disagree, 2=Disagree, 3=Neither Agree nor Disagree, 4=Agree, 5=Strongly Agree).	2	5 (100%)
The instructor was receptive to students' questions and concerns. Scale (1=Strongly Disagree, 2=Disagree, 3=Neither Agree nor Disagree, 4=Agree, 5=Strongly Agree).	2	5 (100%)
Please state your opinion about the usefulness of the information you have learned. (1= Not Useful, 2=Somewhat Useful, 3=Neither Useful nor Useless, 4=Useful, 5=Very Useful).	2	4.5 (90%)
Please state your Overall Attitude/Feelings about the course. Scale (1=Not Enjoyable, 2=Somewhat Enjoyable, 3=Neither Enjoyable nor unenjoyable, 4=Enjoyable, 5=Very Enjoyable).	2	4.5 (90%)

It was clear that throughout the online course, as an instructor, I was receptive to students' questions and concerns, with questionnaire results stating that 100% of my students strongly agreed with this claim (Table 3.). Additionally, this course increased student knowledge, which was made evident by the questionnaire results indicating that 100% of my students strongly agreed that this course increased their knowledge (Table 3). Furthermore, in pursuing inquiry with the guide of my sub research — "What are the attitudes of participating students towards this online science course?" — knowledge from this online course was useful to students, given that the results from the questionnaires showed that all study participants, as an average, viewed the course as somewhere between useful and very useful (Table 3). Similarly, on average, study

participants stated their overall attitude about the course was somewhere between enjoyable and very enjoyable (Table 3).

Students' self-assessment of how well they understood essential course concepts was determined by interpreting the results of questionnaires and is graphically illustrated below:



(This is the Correct Response)

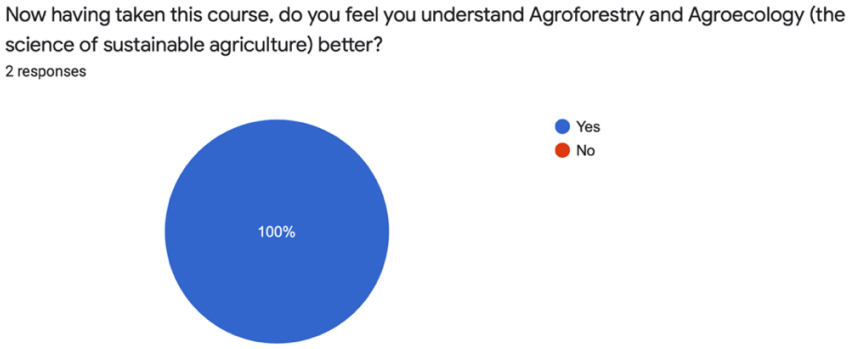
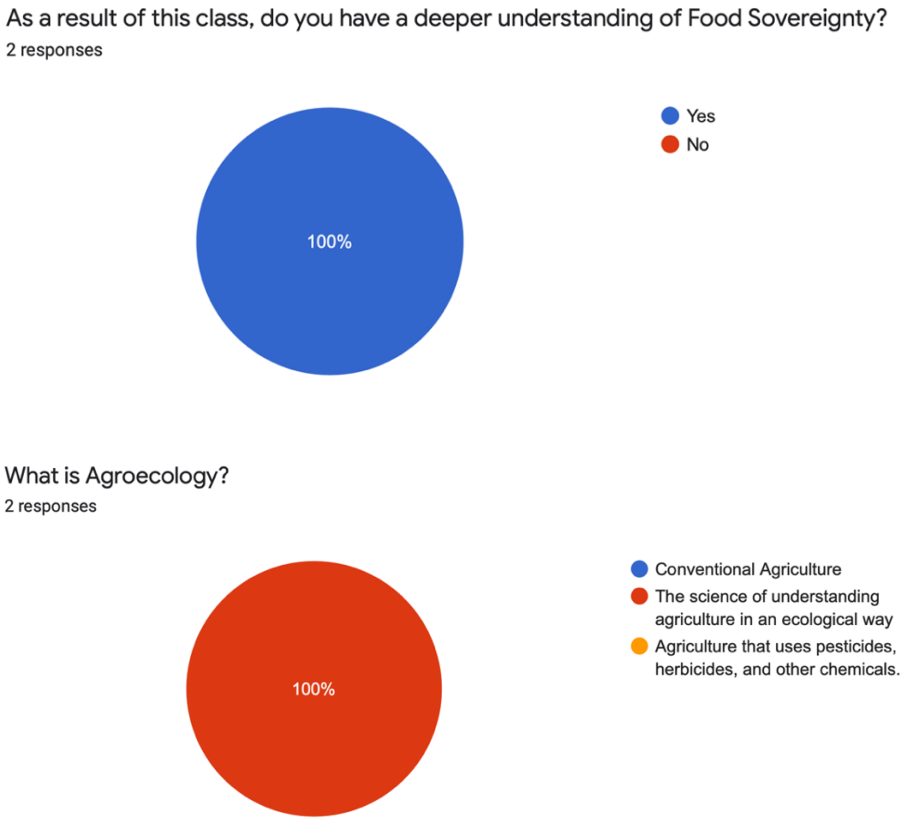


Figure 5. Questionnaire results of students' self-assessment of how well they understood essential course concepts.



(This is the Correct Response)

Figure 5 (continued). Questionnaire results of students' self-assessment of how well they understood essential course concepts.

As a result of the course, students gained a proficiency of the essential course concepts, such as intercropping. Thus, the results from the questionnaires answered my research question, to what degree do students understand the science concepts taught? For example, the questionnaires' results highlighted that 100% of students correctly understood that intercropping is the process of cultivating two or more crops together to foster a synergetic relationship (Figure 7). Comparably, students understood Agroecology to a higher caliber upon completion of the online science course. This level of student

understanding of agroecology was exemplified by the questionnaire results showing that 100% of course participants correctly asserted that agroecology is the science of understanding agriculture ecologically (Figure 7).

Additionally, 100% of student participants indicated on the questionnaires that, having taken this course, feel they have a better understanding of agroforestry and Agroecology (the science of sustainable agriculture). Lastly, due to completing this course, students cultivated a greater knowledge of food sovereignty. Results from the questionnaires indicated that 100% of study participants gained a deeper understanding of food sovereignty as a result of taking this course (Figure 7.). Results from the Questionnaires revealed that 100% of student participants strongly agreed that they increased knowledge due to this course.

Table 4. Student responses to open-ended questions from questionnaires.

1. What has been your most favorite part of the course? • "The video 'Gathering'" [i.e., the documentary film, "Gather." • "The knowledge and understanding of this course. I really like how resourceful it was."
2. Please share your thoughts/feelings about the course and David's teaching style. • "What can a person possibly say except, that Mr. David Sussberg, is a kind, patient, very intelligent in his field. GREAT teacher." • No response.

Students were given an opportunity to ground scientific theory in a culturally relevant and meaningful way by applying a mixed multimedia course design that included videos and documentaries, interactive websites, articles, and books. For example, one student's response to the open-ended questions from the end-of-course questionnaires illuminated that their most favorite part of the course was watching the

documentary film, "Gather." Another student participant shared that their most favorite part of the course was "The knowledge and understanding of this course. I really like how resourceful it was." The last open-ended question of the questionnaire elicited the following response regarding my teaching style: "What can a person possibly say except, that Mr. David Sussberg, is a kind, patient, very intelligent in his field. GREAT teacher." The only outlier of the questionnaire analysis was a "No response" to the opened end: "Please share your thoughts/feelings about the course and David's teaching style."

Student Interviews

Data analysis for my two student interviews began once I finish the time-consuming albeit vital process of transcribing the recorded interviews. Subsequently, I carried out the process of organizing and analyzing the noticed patterns and outliers of students' attitudes and understandings of the science course content while simultaneously assessing my level of capability as a facilitator. Additionally, I searched for and selected quotes that accurately depicted students' overall feelings and thoughts about my course.

The student interviews conducted garnered a sincere perspective of the course design's effectiveness for students learning of specified science concepts, which simultaneously allowed me to assess my teaching style's effectiveness. For example, when I asked my student Teri, how would you describe my teaching style? She stated the following:

> You're a very good teacher. I don’t have any complaints about your style, I was trying to think of a good word to praise you because you're so patient and to me, no question is stupid. Not everybody knows everything.

I asked JC (who is majoring in business management and accounting at BCC) to also describe my teaching style and he elaborated:

> You are really energetic. I really like your style. I definitely feel like you are tentative, and you moved at a pace that's not super-fast. I don't want to say, you were holding my hand, but it's like you're made sure I understood. Dude, honestly, thank you for teaching me, like sharing your wisdom!

I inquired from JC, if the course design and my teaching style were a positive experience for him, and he responded:

> Yes, I honestly say they were. Definitely, most Definitely. I was actually really excited learning about the different farming styles from the different indigenous tribes that you've worked with. Overall, like seriously, I had zero to no knowledge of these plantings at all, so I learned because I got to see this in action. I feel like one of the really positive influences that I will take away from this course is learning how to plant in my area, and not have it like swept away by the wind. Dude, it was a pretty cool course.

Similarly, the course design and my teaching style also appeared to have positively affected Teri, which she expressed in the following words:

> Oh, yeah, it was! Why, because of my health, and it taught me how to plant without having to be, like, how would you say a Western planter. I could be an Agroecology planter. I am a Pancreatic Cancer Survivor, which is very rare and I'm always looking for plants, learning a lot for my own health and boy I've come across a lot since I took this class. I mean a lot of the plants you've talked about or that we seen in the videos and stuff [readings] are major components in helping you with your pancreas. Yeah, so when I was doing this class, it's like are you kidding me? I could be drinking this licorice tea, and it grows right by our house. It's just like oh wow I've learned a lot! Amazing class! So yeah, it's hard to critique you because you're just really a good person. I appreciate that and it's amazing you have such a good heart, and you are so young! I learned a lot and enjoyed the structure of the course and everything, I have, and I'm not trying to blow smoke, I'm just telling you how I see it.

> Furthermore, I asked Teri, in her personal opinion if I was an effective teacher?

Teri replied:

> Well, oh yeah! Um, that just kind of falls in, you know, it's kind of like yeah, you have to be an effective teacher in order for us to learn all that stuff! So yeah, you were very effective. And as an effect, we learned all this stuff. I did anyway.

Similarly, JC illuminated that I was an effective educator by expressing the following:

> I do feel as if you are an effective instructor because dude like I really felt like you really made sure that I had an understanding, of what we were learning. You know, it wasn't like you were just passing information and trying to move me along. It was like hey man do you actually understand what we're learning? And then you really broke it down and I actually did understand what we were learning. And, if I didn't understand, I definitely felt more than welcome to ask.

It was interesting when I asked JC how this course has changed his understanding of the world? In a non-direct manner, he shared his experience learning from me (a non-native) by expressing the following:

> So, there's this separation, it's blatant racism is what it is. Some Native Americans, they do not like being taught indigenous things by non-indigenous peoples, so it's like you get negative views. We throw the label indigenous farming on this, but it's like you know when you're taking inspiration from something and you add something on to it. Does it then become yours? It's almost like everything is shared, you know, like in the world. We're sharing everything and that's what we have to remind ourselves, because as Indigenous people like we didn't have ownership, we shared everything that we had, and it's time that we remind each other of that. It's really cool now to be learning now from anyone. If the information is worthwhile, it's good to learn from anybody.

In contrast to JC, Teri had the following to say about has this course changed her understanding of the world:

> Oh my gosh, you know what, it seemed like the world's going to hell in a handbasket. That's how I see it. And it's just like how come you guys can't see? What I seen you know like why can't we all do what it would take to survive? I mean, you've got to find a way to survive in to learn about the plants and the trees and everything that's around you. I always wonder about how people would survive without electricity, even. I mean, they don't have a clue. Yeah, they don't know how to eat. If they shut down all the McDonald's and Burger King's and all those, what are they going to do?

I told Teri, “Right? One of the reasons I created this class was to get people back to the basics of knowing how to grow food in a scientific and holistic manner.”

When speaking about her PAR project, Teri explained the following:

> At first, I didn’t like doing those concept maps, and then I go well you know what, so I took my stuff that I needed, and I built my concept map around it, so I can just grow all this stuff with agroforestry. Yeah, so I built agroecology for myself, so I'm going to grow it myself. And because where I live there's a little hill and then it's kind of like a swamp because I was getting moose back there and it's almost kind of like tropical-like, humidity type-stuff and the berries grow thick, so I'm going to put everything else around it that I need [chokecherries/elderberries/licorice etc.] to grow around there. I could do this because I was thinking, at first, you know you got to have everything in a row, but you don't. You can grow it however you want.

Additionally, I asked Teri to reflect on the main concepts that she learned, and she shared the following:

> Agroforestry is the best thing ever! Yeah, I always thought Food Sovereignty was just your own, nobody else’s, you didn’t share you, didn’t do anything, it was just contained to yourself. Just one thing. I didn't know that it was a group thing, that belonged to everybody, because you know when they say oh, we're a sovereign nation. You know, it means it's just like one. It doesn't mean, like, everything, like the community. Yeah, so that was an eye opener for sure.

More specifically, I asked Teri did she learn a variety of science concepts throughout this course? She simply stated:

> I'm sure I did, but I wouldn’t know if I did, I mean I learned about Agroecology you know, and I didn't know it was a science thing, you know, so it's like yeah, I did some science but I didn't know I did science. It’s like you know how somebody says about something, oh that’s science. So, yeah, I've learned a lot!

Similar to Teri, JC expressed central science concepts that he learned, although initially he vaguely said, “I definitely learned a lot, yes there were many different concepts that I

had learned." Moreover, JC does specifically used the scientific term of 'intercropping,' expressing his clear understanding of the concept by replying:

> The intercropping thing blew my mind, actually, just to say the least. Yeah, that one was crazy, like I learned those different plots with different plants which essentially help one another, like one would shade the other or this one would protect from the wind, or one would help with either the pH balance or acidity.

Furthermore, JC explained that before the course:

> Whenever I thought of plants, I never imagined that they helped each other grow. I always thought that they were taking away from each other's nutrients, like they weren't able to grow together. I knew some plants are acidic and change the soil in which it would grow, making it so some other plants couldn't grow. But I never knew that that that plant would be able to feed another plant. I just had to know which type of plant that it would help out, which type of plants are going to be helping each other when they're grown next to each other.

Additionally, while JC does not explicitly express "conventional agriculture," he proficiently described conventional agriculture's destructive practices on soil heath by saying:

> Through digging the soil up, like what we've done through the western farming, there's damage being done to the actual farmland over time, there's no nutrients within the land, like helping itself anymore. So, I want to know more plants to grow that are just good for the earth.

When I asked JC, what was the most meaningful part of the course for him, he excitedly responded:

> This is the solution, this agroforestry, learning how to grow our own foods, like learning, about portion control, learning what foods to eat, where to get them. People make the excuse, oh it's too expensive to eat healthy. Well, we can grow. We have a place to grow food. We can do this, we have the water coming through, we can make this a reality. Maybe we can even outreach to other tribes, if possible. We can actually start making like a very huge difference. I always hear like so many roadblocks, but with what you've explained, they've kind of broken a lot of these roadblocks for me. So I'm skeptical but excited to see myself grow some things! I want to see life come

> forth and come from seeds. I want to be able to plant and I want to get with other people you are plant people to teach me more things!

I also inquired with Teri what was the most meaningful aspect of the course for her, and she responded, “I liked that movie, ‘Gather.’ Yeah, I really, I really liked that one.” I asked the probing question, what about it, did you love so much? Teri replied, “Oh, it’s just that they were so self-sufficient. Everything they had was just either dug up or eaten. Eating the rats was over the top, but I mean they ate it.”

The 2020 documentary film “Gather,” depicted various Indigenous Nations’ Indigenous food systems. In the film, Twila Cassadore, a traditional Apache medicinal plant knowledge keeper catches wild rats in the desert for food. The wild rats eat certain plants that contain medicinal properties that the human digestions system cannot digest, but by ingesting the wild rat she is able to safely absorb the medicinal nutrients from the plant. Teri pointed out another meaningful element of the online course for her was a Zoom webinar which hosted a local Blackfeet expert working on food sovereignty work, Teri explained that “Miss Antelope, her presentation, and talk was very encouraging, she was really interesting.”

I asked JC, did the design of the course, help or hinder his ability to learn science concepts? JC responded:

> I would say that the course’s design has helped my overall understanding of the science of agroforestry, because I had little to no knowledge on actual planting. I only planted maybe like a handful of things over my lifetime. Yeah, this was a great push forward in the direction of learning different types of forestry and agriculture.

While JC’s response highlights that the course design enabled him to learn the science of agroforestry, he did not specially address how the course design helped his

understanding of the science concepts taught. On the other hand, when I asked Teri this same question of "How did the design of the course, help or hinder your ability to learn science concepts?" she said the following:

> It didn't hinder in anyway, because it just, kind of was in order. You know you've got the idea and then you got the [components of] Agroecology and you know it just kind of went in steps, learning the soil, so we know what we need to grow, how to take care of the soil, and get the soil going and stuff, so it's not a hindrance, it's a process I would say. I like structure, I like to be focused, and I like to have things in order and neat. Yeah, and then you have no problems.

I further elaborated to Teri that in online education they call each week's consecutive section, sequential modules, and I asked her if she thought the modules built into each other? She said, "I do, yes, and then there's like little treats of stuff along the way, you know, like oh man I didn't know that!" Teri went on to explain how the course design was like a really good soap opera by saying the following words:

> I don't watch soap operas but, like, I couldn't wait for the next time, the other part. You gotta wait till the next time, the next time and it's just like come on, Let's get it all in one day.

Although she could access the whole course at any given moment, digesting all the weekly modules in one day would obviously be impossible. Moreover, Teri explained "Yeah, I was anxious for this class, because I just was wanting to know how I could do myself better." I told her that is the beauty of education and she replied "Especially if you're interested in it! But if, you're forced to do it, it's just like are you kidding? I don't want to do that. But if it's something you want and something you're interested in, it's really exciting." When I asked JC what were some of the main ideas he learned from the course? He shared:

> Agroforestry and intercropping are like the main two things that I've really learned. Yes, intercropping was the really main thing that I really took from the class. Just because, like the wind is the biggest thing when anybody talks about planting, they bring up the wind. Like seriously, a huge thing here is the wind man, and so when you explained about these different types of grasses that will actually, you know, hold soil and Zuni Bowls in place so that we can make our chokecherries and elderberries.

JC also shared that he learned the "The layering system that they would go for a farm," which refers to multistory agroforestry systems, in which plants are intercropped at different heights "layers," mimicking the ecological structures of forests, e.g., canopy, understory, etc. Furthermore, I asked JC if he had an understanding or plan of applying science concepts that he learned from this course in his life now or in the future, and he shared the following with me:

> My father lives on like a 40-acre plot, we have freedom to kind of play with this area. There's a lot of things that I want to do with it, so I'm just like a sponge just learning, really wanting to learn more and get more into the understanding of things. So, I'm learning what other foods I can grow along with berries and different types of vegetables that I can grow. Because, like I said there's 40 acres, just on my plot alone. There really is so much potential. Like sometimes we feel like we're alone, but we're not alone. And so, my goal lately, as of these past few years is to get the people together so we can start tackling some things. So, that is one of my dreams, I want to learn how to naturally mulch and till the soil.

Overall, student interviews afforded me a comprehensive and in-depth awareness of my students' perspectives of participating in my course and what they took away from the course.

CLAIMS, EVIDENCE, AND RESASONING

Claims from the Study

Given that many schools have moved from face-to-face instruction to online learning, there is a great demand for original and inventive online environmental science curricula. To help fill this educational gap, I designed and taught an online Brightspace (D2L) science course. A mixed methods research design assessed the online agroecology course design and my teaching capability for effective student learning. In particular, the process of conducting my questionnaires (qualitative research) and student interviews (qualitative research method) elicited an excellent assessment of the level of student understanding of the science concepts taught and gauged students' attitudes towards the course and my facilitation effectiveness for student learning. This mixed methods approach answered my main action research focus question: What are the outcomes of designing and teaching an innovative online science curriculum?

In seeking to answer my sub-research question's objective of gauging students' attitudes towards this online science course, student participants expressed that the sequential course modules (Appendix E) went in a logical order, covering the components of agroecology and building into one another, which I feel enhanced student learning. Study participants disclosed that the course's multimedia design of using readings, videos, and Blackfeet guest speakers made the course meaningful. The course's design enabled students to learn the science of agroecology; one student shared that the course was "a great push forward in the direction of learning different types of forestry

and agriculture." Another study participant stated, "I learned a lot and enjoyed the structure of the course and everything."

Furthermore, designing and teaching an innovative online science curriculum was comprehensibly an enjoyable experience for course participants and the instructor. Likewise, the questionnaires revealed that course participants expressed their overall attitude about the course ranged between enjoyable and very enjoyable. The questionnaires also showed that 100% of student participants strongly agreed that they increased knowledge due to this course. Comparably, course design and my facilitation proved to be effective for student learning, with one student saying, "You have to be an effective teacher in order for us to learn all that stuff!" Another student stated:

> I do feel as if you are an effective instructor because dude like I really felt like you really made sure that I had an understanding, of what we were learning. You know, it wasn't like you were just passing information and trying to move me along. It was like hey man do you actually understand what we're learning? And then you really broke it down and I actually did understand what we were learning.

Overall, the Blackfeet Community College study participants were engaged and enjoyed this online science course. Moreover, questionnaires and student interviews revealed that students were positively impacted and developed a broader understanding of scientific theory and praxis, which consequently answered my sub-research questions: "To what degree do students understand the science concepts taught?" Student participants thoroughly learned the central science concepts of agroecology, agroforestry, and intercropping. For example, the questionnaire results showed that 100% of students correctly understood the concept of intercropping. Also, one student responded in the following manner:

> Agroforestry is the best thing ever! The intercropping thing blew my mind, actually, just to say the least. This is the solution, this agroforestry, learning how to grow our own food… Yes, intercropping was the really main thing that I really took from the class.

In response to my sub-research question's intention of discovering how this experience has impacted me as a teacher, students used the following words to describe my teaching style: "energetic," "tentative," "patient," "you're a very good teacher," and "very intelligent in his field. GREAT teacher." Lastly, students said the following about the course: "I feel like one of the really positive influences that I will take away from this course is learning how to plant in my area, and not have it like swept away by the wind." "Dude, it was a pretty cool course." "Amazing class!"

Value of the Study and Consideration for Future Research

This study can serve as a resource for future MSSE students or anyone interested in learning how to design, facilitate, and assess online Brightspace (D2L) online science curricula for effective student learning. A consideration for future research is looking into collaborations with other Tribal colleges to design culturally appropriate and effective online science curriculum for student learning. Finally, this study and the associated development of curriculum has tremendous value for the field of agroecology.

Impact of Action Research on the Author

Conducting this Action Research project has immensely empowered me as an educator. Appropriately designing, teaching, and accessing my course for student learning effectiveness has significantly enhanced my knowledge and skills in designing and teaching future online courses. More specifically, learning to design an online Brightspace (D2L) course has boosted my confidence and fostered proficiency in future D2L curriculum construction and instruction. Furthermore, the overwhelmingly positive feedback expressed during the student interviews has clearly illustrated that I can effectively instruct college students in agroecology and sustainable food systems via online education.

REFERENCES CITED

Agroecology in Action. (2021, July 10). *Agroecology in action: Agroecology.* http://agroeco.org

Alrushiedat, Nimer and Olfman, Lorne, "Anchored Asynchronous Online Discussions: Supporting Learning Conceptions" (2012). AMCIS 2012 Proceedings. 11.

BDA. (2021, July 10). *Biodynamic Association (BDA: Biodynamics).* https://www.biodynamics.com/what-is-biodynamics

Beetz, A. E. (2011). *Agroforestry: Overview*. Appropriate Technology Transfer for Rural Areas (ATTRA).

Boettcher, J. V., & Conrad, R. M. (2016). *The online teaching survival guide: Simple and practical pedagogical tips.* John Wiley & Sons.

Bowen, M., & Bartley, A. (2013). *The basics of data literacy: Helping your students (and you!) make sense of data.* National Science Teachers Association.

Caffarella, R. S., & Daffron, S. R. (2013). *Planning programs for adult learners: A practical guide.* John Wiley & Sons.

Cajete, G. (2000). *Native Science - Natural Laws of Interdependence.* Clear Light.

Collison, G., Elbaum, B., Haavind, S., & Tinker, R. (2000). *Facilitating online learning: Effective strategies for moderators*. Atwood Publishing.

Denevan, W. M. (1992). The pristine myth: The landscape of the Americas in 1492. *Annals of the Association of American Geographers*, *82*(3), 369-385.

Dunaway, M., & McCarthy, R. (2015). Case study: Lessons learned in launching an integrated online graduate business analytics program. *Issues in Information Systems, 16*(4), 152-156.

FAO. (2021, July 10). *The Food and Agriculture Organization of the United Nations: Agroecology*. <http://www.fao.org/agroecology/overview/en/>

He, W., Xu, G., & Kruck, S. E. (2019). Online IS education for the 21st century. *Journal of Information Systems Education, 25*(2), 1

Indigenous Food Systems Network. (2021). “Indigenous Food Systems” Indigenous Food Systems Network.org. Working Group on Indigenous Food Sovereignty. <https://www.indigenousfoodsystems.org>

Ligteringen, M. (2015). *Institutional change in the corporate food regime*

[Bachelor Project, Internationale Betrekkingen en Organisaties]. Theses and Dissertations at Project Internationale Betrekkingen en Organisaties. https://d1wqtxts1xzle7.cloudfront.net/41553185/BT_FINAL2_extended.pdf

Lovelace, M., & Brickman, P. (2013). Best practices for measuring students' attitudes toward learning science. *CBE—Life Sciences Education*, *12*(4), 606-617.

Méndez, V. E., Bacon, C. M., Cohen, R., & Gliessman, S. R. (2015). Agroecology: A transdisciplinary, participatory, and action-oriented approach. CRC Press.

Ernesto Méndez, V., Caswell, M., Gliessman, S. R., & Cohen, R. (2017). Integrating agroecology and participatory action research (PAR): lessons from Central America. *Sustainability* 9: 1–19.

Mertler, C. A. (2020). *Action research: Improving schools and empowering educators*. Sage Publications.

Mihesuah, D. A., & Hoover, E. (Eds.). (2019). Indigenous food sovereignty in the United States: Restoring cultural knowledge, protecting environments, and regaining health. University of Oklahoma Press.

Nguyen, H. (2018). Sustainable Food Systems Concept and Framework. *Food and Agriculture Organization of the United Nations: Rome, Italy*.

Novak, J. D., & Cañas, A. J. (2008). The theory underlying concept maps and how to construct and use them. Technical Report *IHMC*. Rev 01. Florida Institute for Human and Machine Cognition.

Nyéléni. (2007). <https://nyeleni.org/spip.php?article290> Accessed April 2021.

Palloff, R. M., & Pratt, K. (2011). *The excellent online instructor: Strategies for professional development*. John Wiley & Sons.

Peña, D., Calvo, L., McFarland, P., & Valle, G. R. (Eds.). (2017). *Mexican-origin foods, foodways, and social movements: Decolonial perspectives*. University of Arkansas Press.

Regeneration International. (2021). Regenerative agriculture. *Regeneration International.* <https://regenerationinternational.org/why-regenerative-agriculture/>

Robin, T., & Cidro, J. (2020). Rebuilding cultural identity and indigenous food

sovereignty with indigenous youth through traditional food access and skills in the city. *Indigenous food sovereignty in the United States: restoring cultural knowledge, protecting environments, and regaining health*, 135-151.

Schroeder-Moreno, M. S. (2010). Enhancing active and interactive learning online-lessons learned from an online introductory agroecology course. *NACTA Journal*, *54*(1).

Turner, N. J., Ignace, M. B., & Ignace, R. (2000). Traditional ecological knowledge and wisdom of aboriginal peoples in British Columbia. *Ecological applications*, *10*(5), 1275-1287.

USDA. (2011). What is Organic? The NOP Organic Insider USDA National Organic Program.

U.S. Fish and Wildlife Service (USFWS) (2011). *Traditional Ecological Knowledge for \ Application by Service Scientists.* USFWS. *<https://www.fws.gov/nativeamerican/pdf/tek-fact-sheet.pdf>*

Weber-Pillwax, C. (2001). "What is indigenous research?" *Canadian Journal of Native Education, 25*(2), 166-174.

Wilson, S (2001). Editorial: “Self-as-relationship Indigenous research.” *Canadian Journal of Native Education,* 25(2), 91-92.

Wilson, S. (2008). *Research is ceremony: Indigenous research methods*. Fernwood Publishing.

Windchief, S., & San Pedro, T. (Eds.). (2019). *Applying Indigenous research methods: Storying with peoples and communities*. Routledge.

APPENDICES

APPENDIX A

STUDENT PARTICIPATORY ACTION RESEACH (PAR) PROJECT PLANS

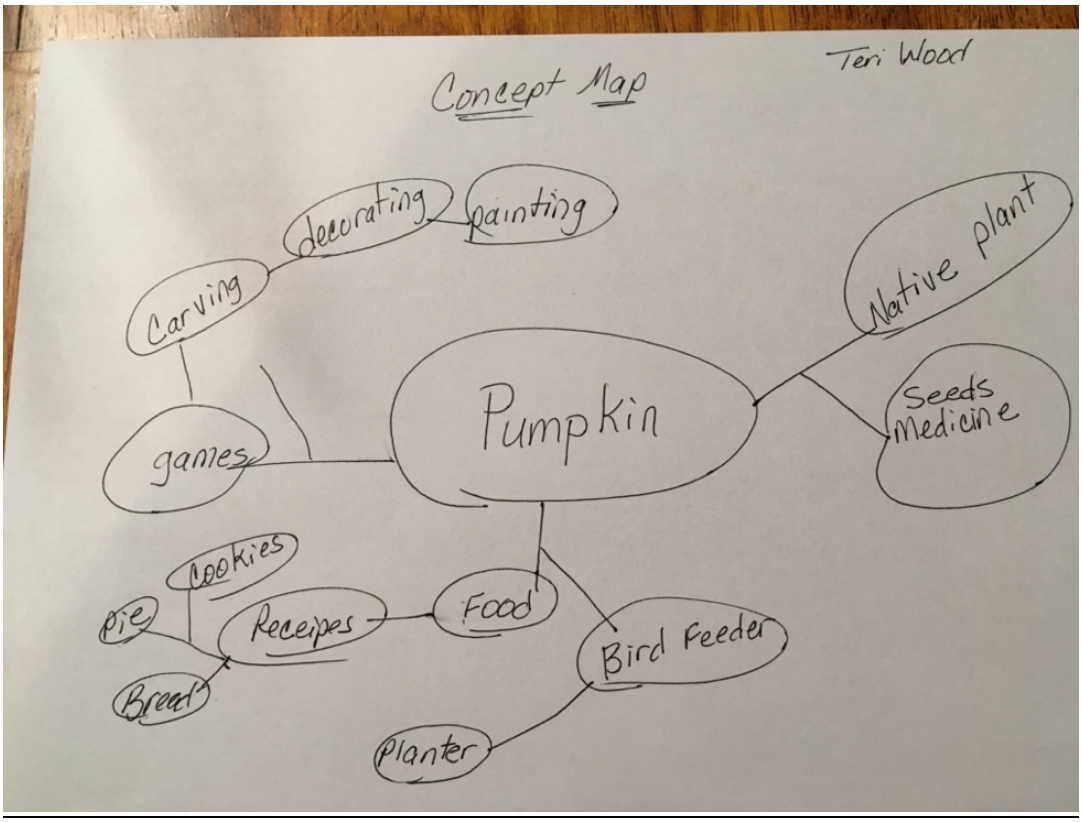


Figure 6. Concept Map of Teri's Participatory Action Research (PAR) Project Plan

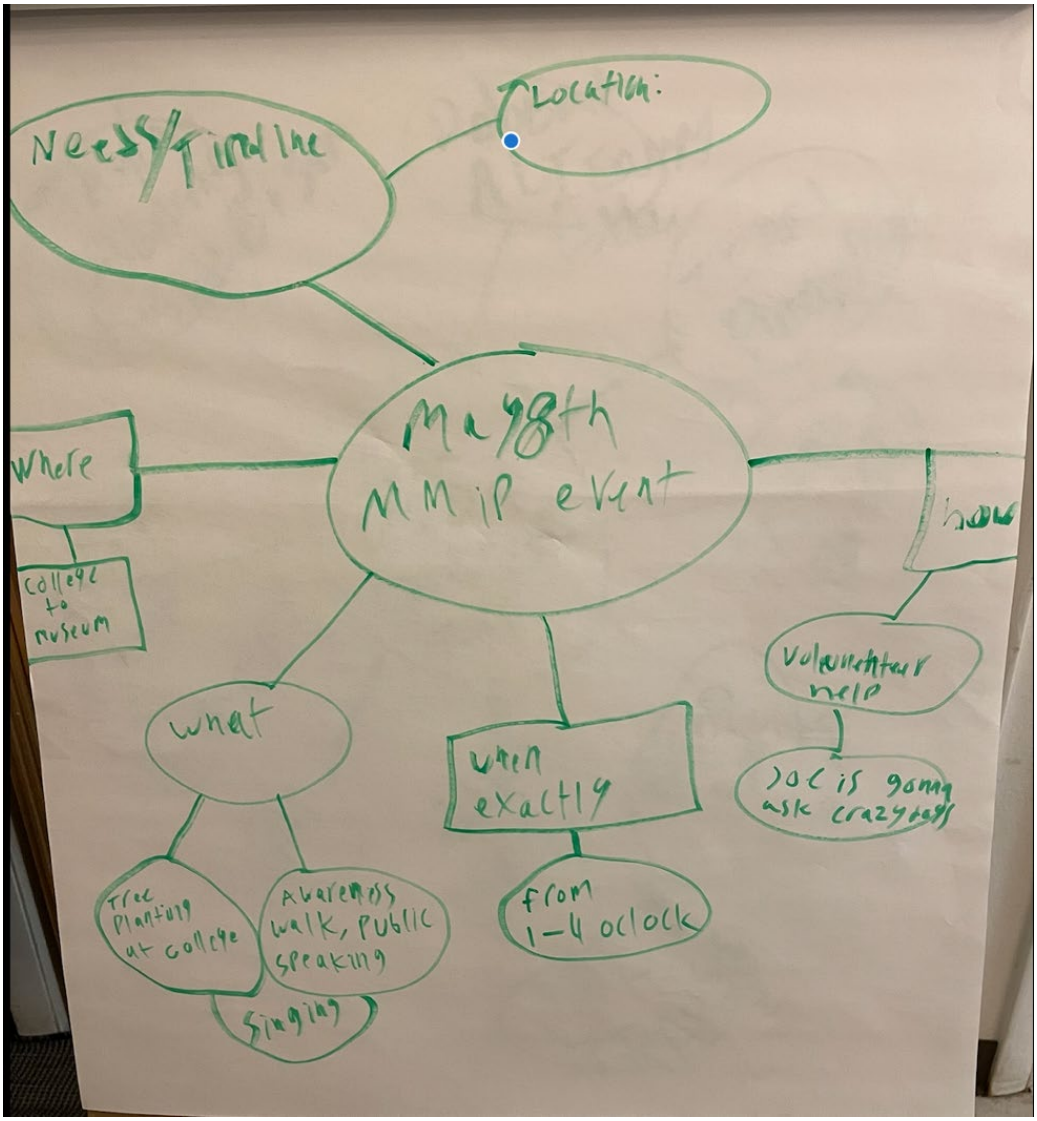
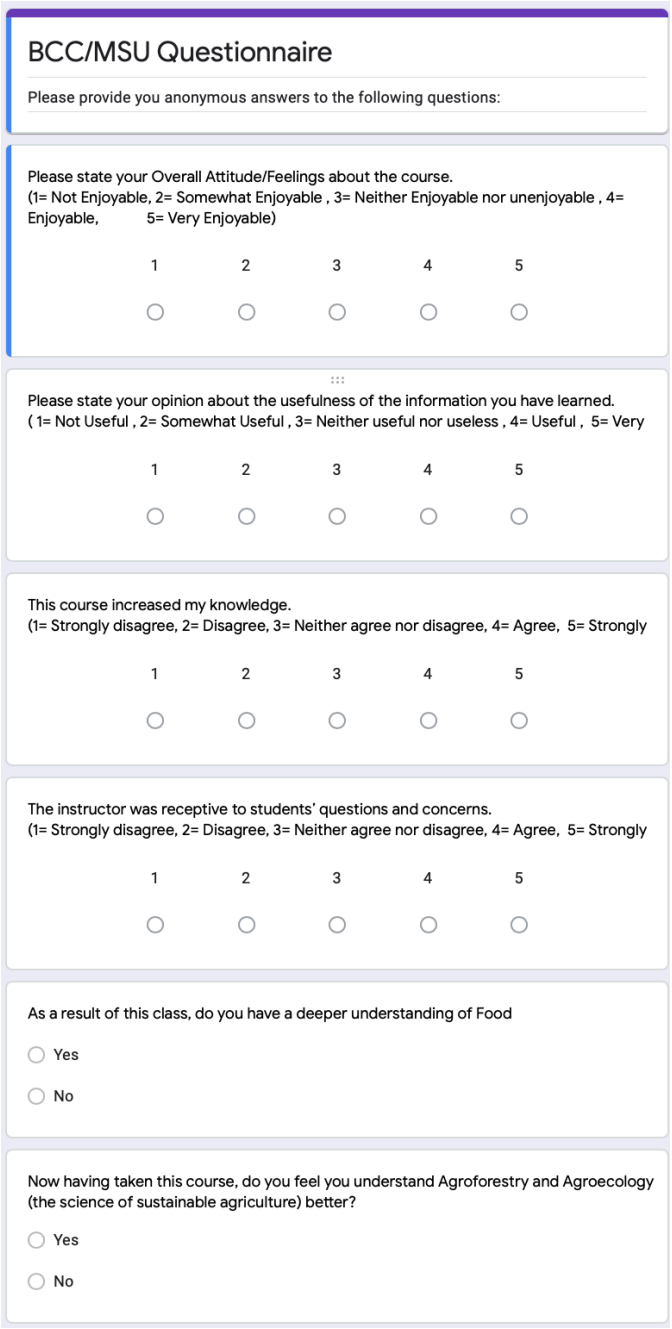


Figure 7. Concept Map of JC's Participatory Action Research (PAR) Project Plan

APPENDIX B

INSTRUMENTS

Questionnaires



BCC/MSU Questionnaire

Please provide you anonymous answers to the following questions:

Please state your Overall Attitude/Feelings about the course.
(1= Not Enjoyable, 2= Somewhat Enjoyable , 3= Neither Enjoyable nor unenjoyable , 4= Enjoyable, 5= Very Enjoyable)

1 2 3 4 5

Please state your opinion about the usefulness of the information you have learned.
(1= Not Useful , 2= Somewhat Useful , 3= Neither useful nor useless , 4= Useful , 5= Very

1 2 3 4 5

This course increased my knowledge.
(1= Strongly disagree, 2= Disagree, 3= Neither agree nor disagree, 4= Agree, 5= Strongly

1 2 3 4 5

The instructor was receptive to students' questions and concerns.
(1= Strongly disagree, 2= Disagree, 3= Neither agree nor disagree, 4= Agree, 5= Strongly

1 2 3 4 5

As a result of this class, do you have a deeper understanding of Food

Yes

No

Now having taken this course, do you feel you understand Agroforestry and Agroecology (the science of sustainable agriculture) better?

Yes

No

Figure 8. Snapshot of Google Forum Questionnaire

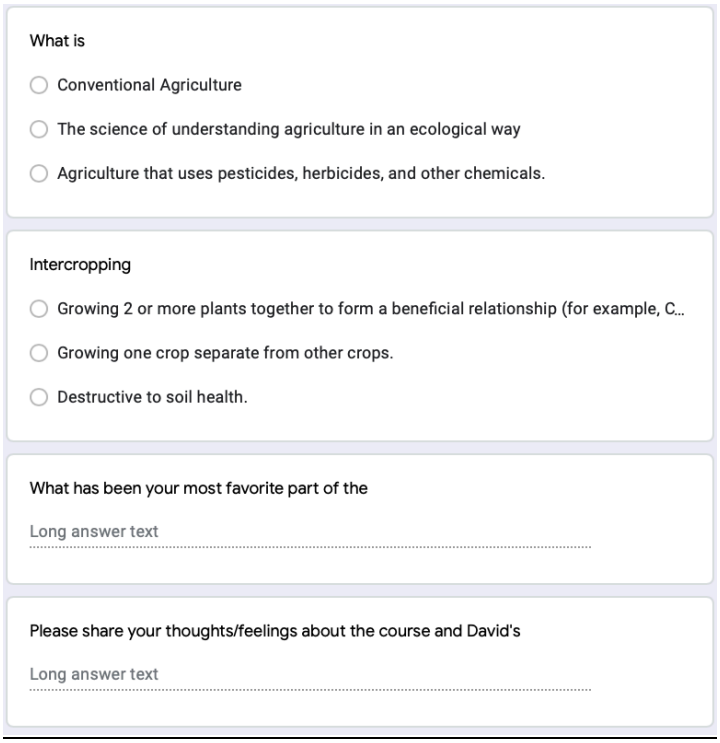


Figure 8 (continued). Snapshot of Google Forum Questionnaire.

Student Interviews Questions

1.) Throughout this course, did you learn a variety of science concepts?
    a. Please explain why you answered the way you did in the above question.
2.) No need to describe in detail, but what main concepts did you learn?
3.) How did the design of the course help or hinder your ability to learn science concepts?
    a. Why or why not do you think this happened?
4.) How did my teaching style influence your ability to learn these science concepts?
5.) Do you have an understanding of how the science concepts from this course could be applied in your life now or in the future?
    a. Please explain why or why not.

Student Interviews Questions (continued)

6.) How would you describe my teaching style?
    a. What parts of it helped you; what parts didn't help you?
7.) Were the course design and my teaching style a positive experience for you?
    a. Why/How?
8.) From what you learned throughout the course, what was the most meaningful parts for you?
    a. Why do you think this was true?
9.) In your personal opinion, was I an effective Instructor? Why or why not?

a. How could I improve?

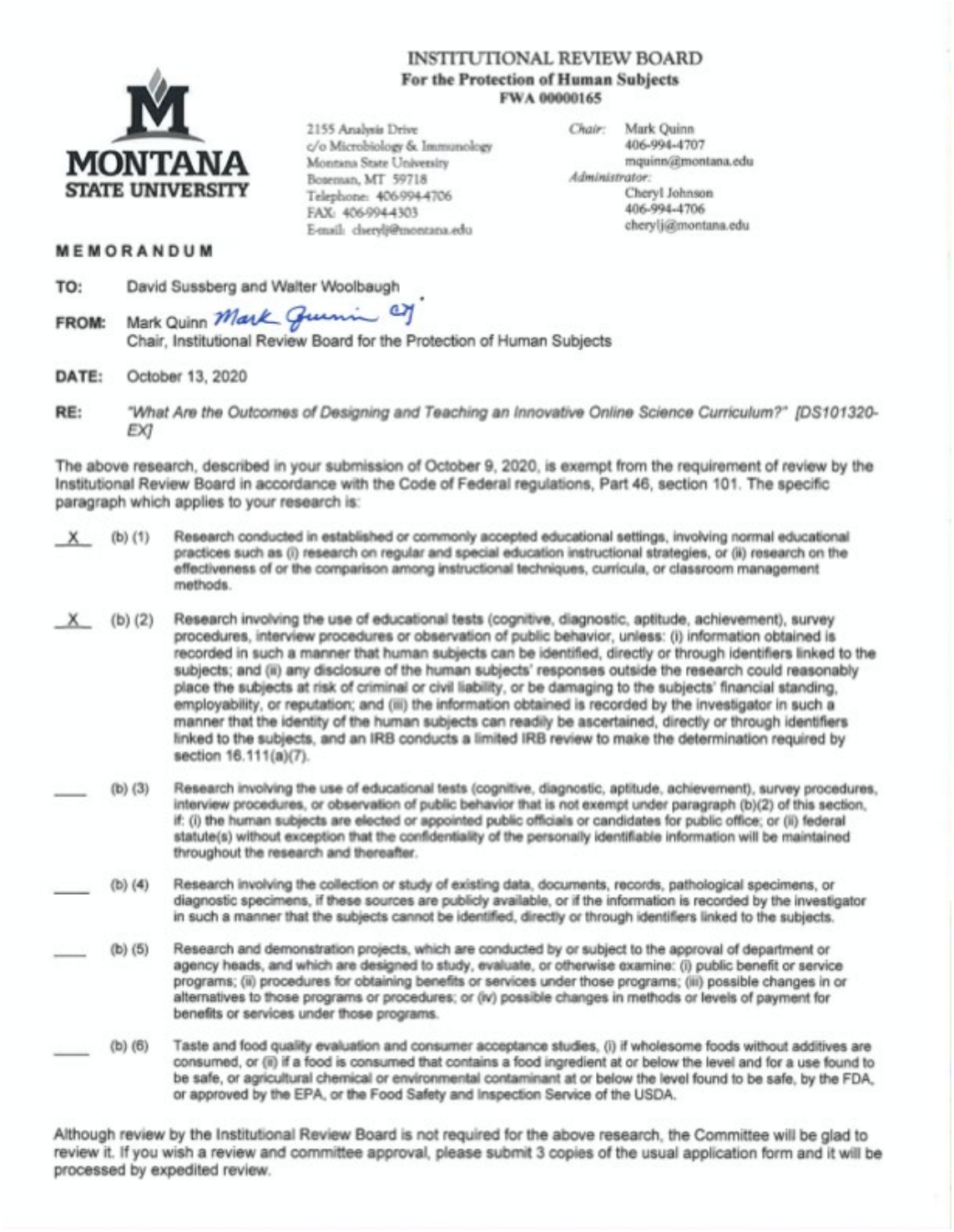
10.) How has this course changed your understanding of the world?

a. The science concepts and case studies, please give me feedback.

APPENDIX C

MONTANA STATE UNIVERSITY INSTITUTIONAL REVIEW BOIARD'S

RESEARCH METHODOLOGY EXEMPTION



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

MONTANA STATE UNIVERSITY

2155 Analysis Drive
c/o Microbiology & Immunology
Montana State University
Bozeman, MT 59718
Telephone: 406-994-4706
FAX: 406-994-4303
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Chair: Mark Quinn
406-994-4707
mquinn@montana.edu
Administrator:
Cheryl Johnson
406-994-4706
cheryl@montana.edu

MEMORANDUM

TO: David Sussberg and Walter Woolbaugh

FROM: Mark Quinn Mark Quinn CJ
Chair, Institutional Review Board for the Protection of Human Subjects

DATE: October 13, 2020

RE: *"What Are the Outcomes of Designing and Teaching an Innovative Online Science Curriculum?" [DS101320-EX]*

The above research, described in your submission of October 9, 2020, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

X (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

X (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation; and (iii) the information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by section 16.111(a)(7).

___ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

___ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

___ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

___ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

Figure 9. Montana State University Institutional Review Board's Research Methodology Exemption

APPENDIX D

GRAPHICAL REPRESENTATION OF QUESTIONNAIRE RESULTS

OF STUDENT ATTITUDES TOWARDS THE SCIENCE COURSE

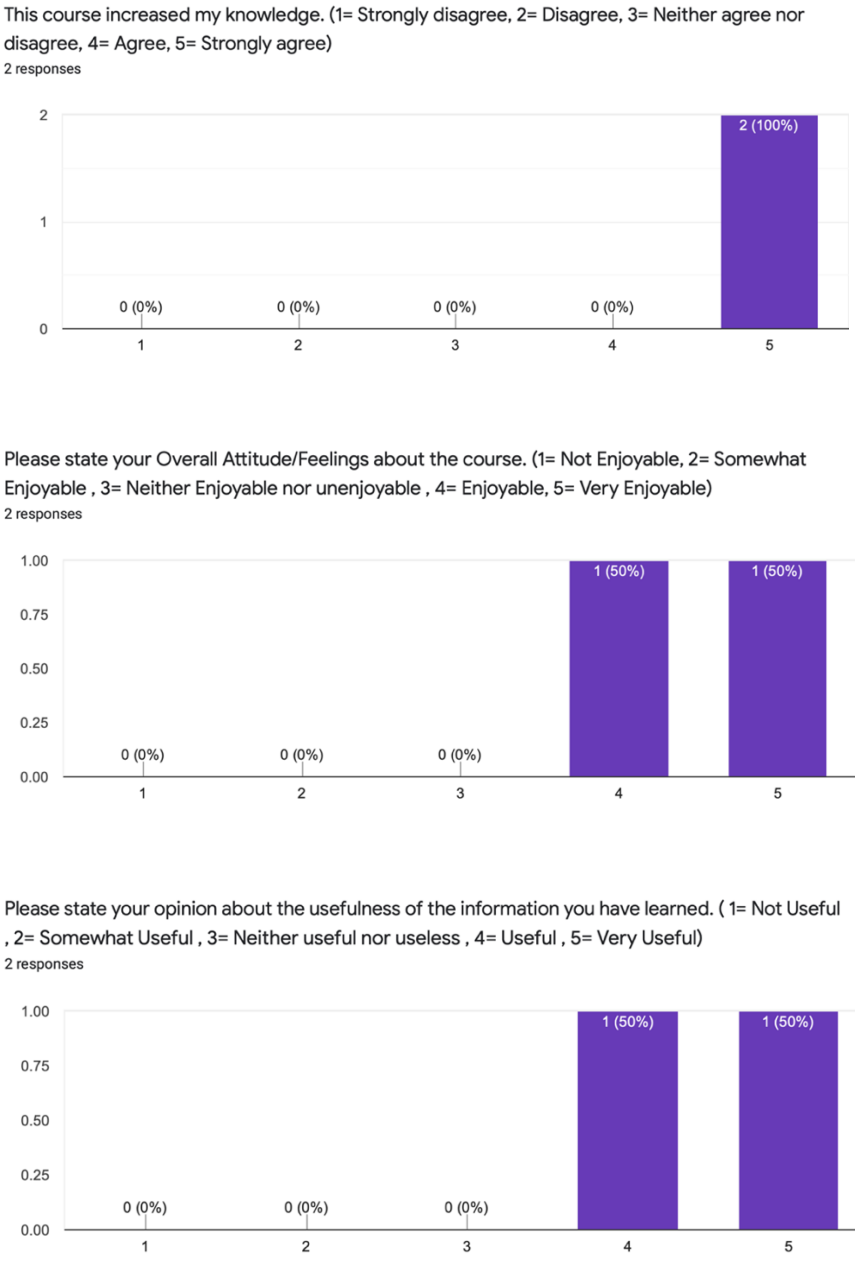


Figure 10. Graphical representation of questionnaire results of student attitudes towards the science course.

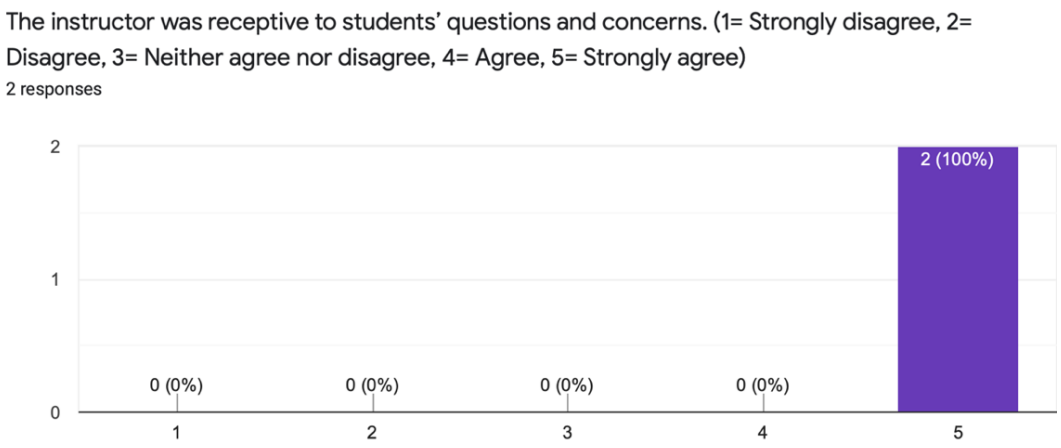


Figure 10. (continued). Graphical representation of questionnaire results of student attitudes towards the science course.

APPENDIX E

SEQUENTIAL MODULES (COURSE OUTLINE)

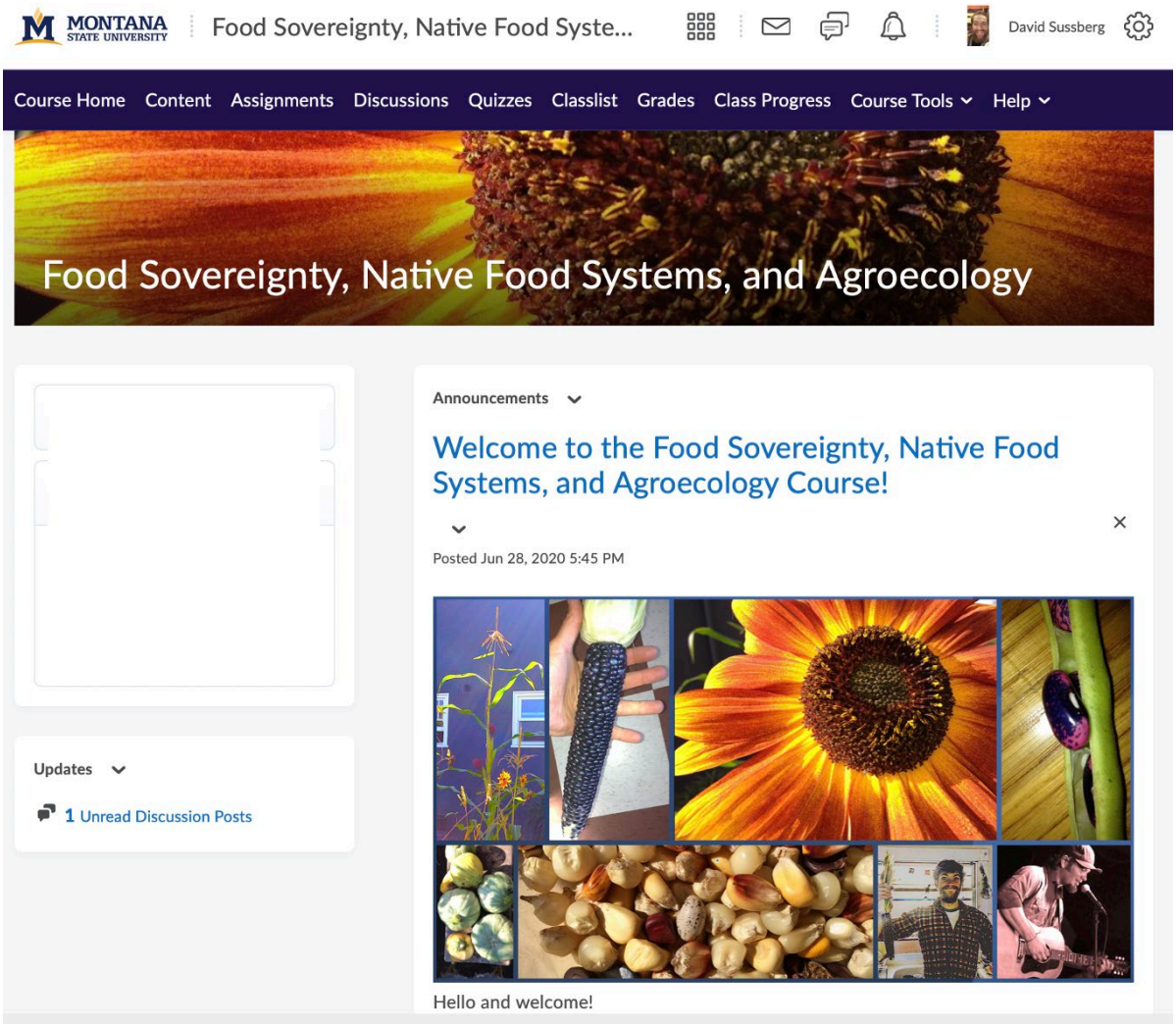


Figure 11. Screenshot of the Food Sovereignty, Native Food Systems, and Agroecology Brightspace (D2L) Course's Welcome Page.

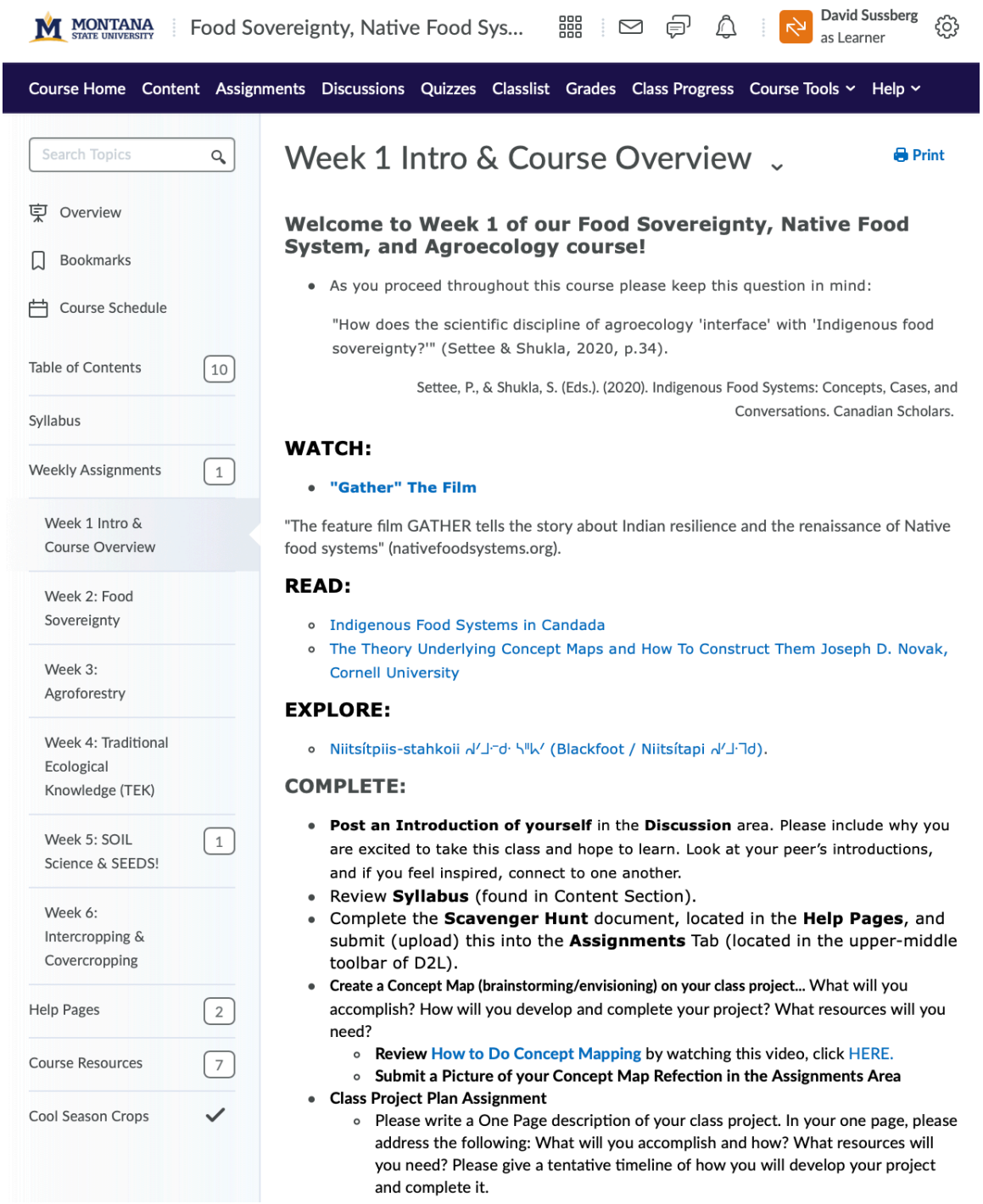


Figure 12. Screenshot of the Food Sovereignty, Native Food Systems, and Agroecology Brightspace (D2L) Course's Week 1: Intro & Course Overview.

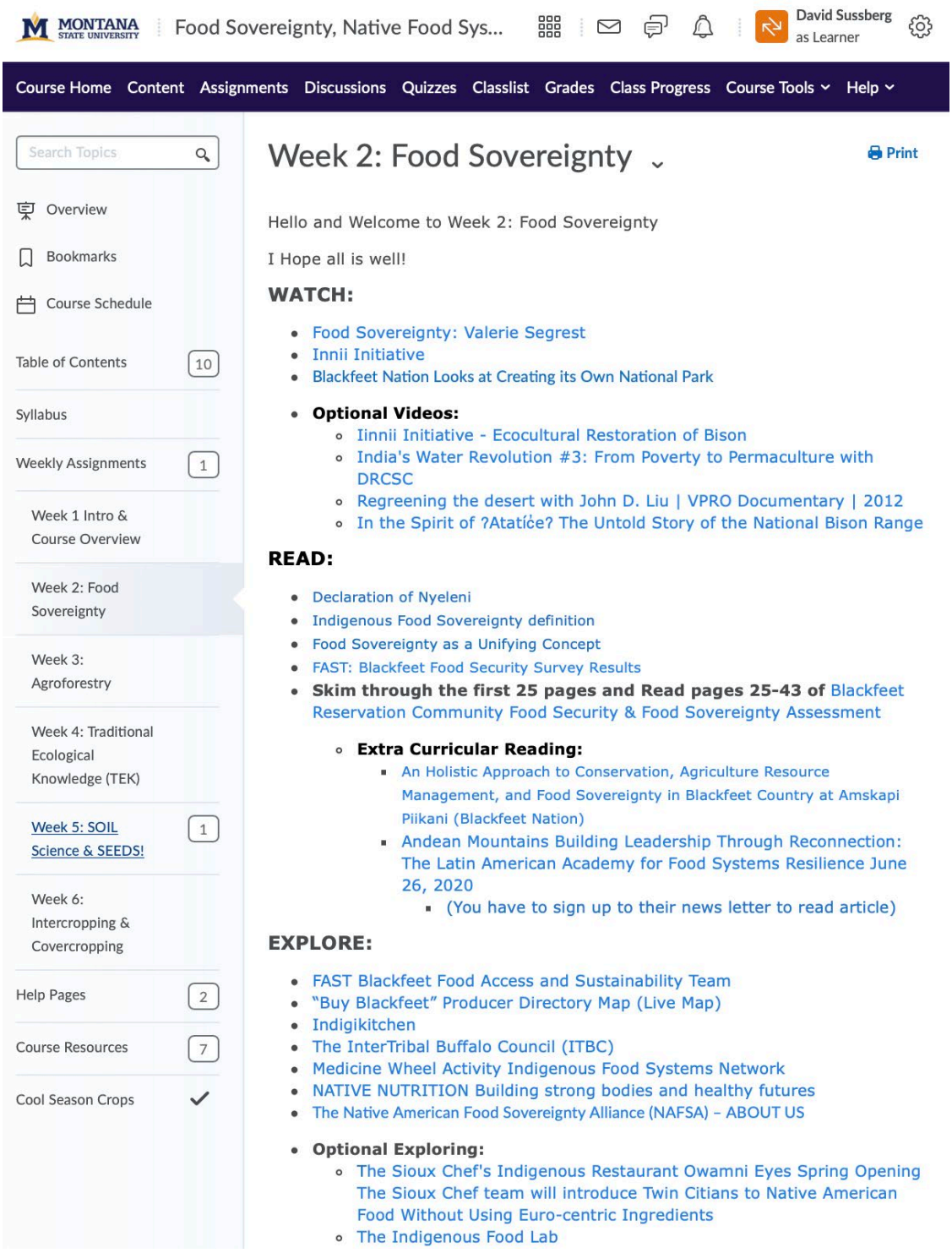


Figure 13. Screenshot of the Food Sovereignty, Native Food Systems, and Agroecology Brightspace (D2L) Course's Week 2: Food Sovereignty.

COMPLETE:

- In the **Discussion Area** post your own definition of what Food Sovereignty is and why it is important to you.
- **Concept Map Refection:**
  - Create your own **Concept Map** reflecting on this week's material/experience, answering the following 2 questions:
    - What did you find meaningful/important?
    - What major concepts/ideas did you learn or relearn differently?
  - **If you need to Review How to Do Concept Mapping please watch this video, click HERE.**
  - **Submit a Picture of your Concept Map Refection in the Assignments Area before Wednesday April 7th at 11:59pm**
    - Thank you

Please read the following quote from Saokio Heritage (2017)'s report "Ahwahsiin (The Land/Where We Get Our Food): Traditional Foods and Contemporary Food Sovereignty on the Blackfeet Reservation," thank you:

"Suggestions to increase food sovereignty and community wellbeing came from interviewees, who all grew up in the area and are elders, and FAST Blackfeet's Community Food Sovereignty Assessment. They include:
• Selling locally hunted wild game and locally processed bison at Glacier Family Foods, the tribally-owned grocery store.
• Developing more robust food safety laws to increase tribal food production.
• Establishing a large community garden that will help to feed the neediest people on
the Reservation, particularly elders and young people.
• Providing and supporting regular education opportunities on both nutrition and health, as well as on traditional food gathering and recipes.
• Making fast food less available.
• Supporting community members in pursuing degrees in science, technology, and
health to promote studies in food sovereignty and TEK.
• Supporting and implementing further studies and projects on food sovereignty" (p.6).

How can our class and BCC's Farm help to accomplish these community goals?

Figure 13. (continued). Screenshot of the Food Sovereignty, Native Food Systems, and Agroecology Brightspace (D2L) Course's Week 2: Food Sovereignty.

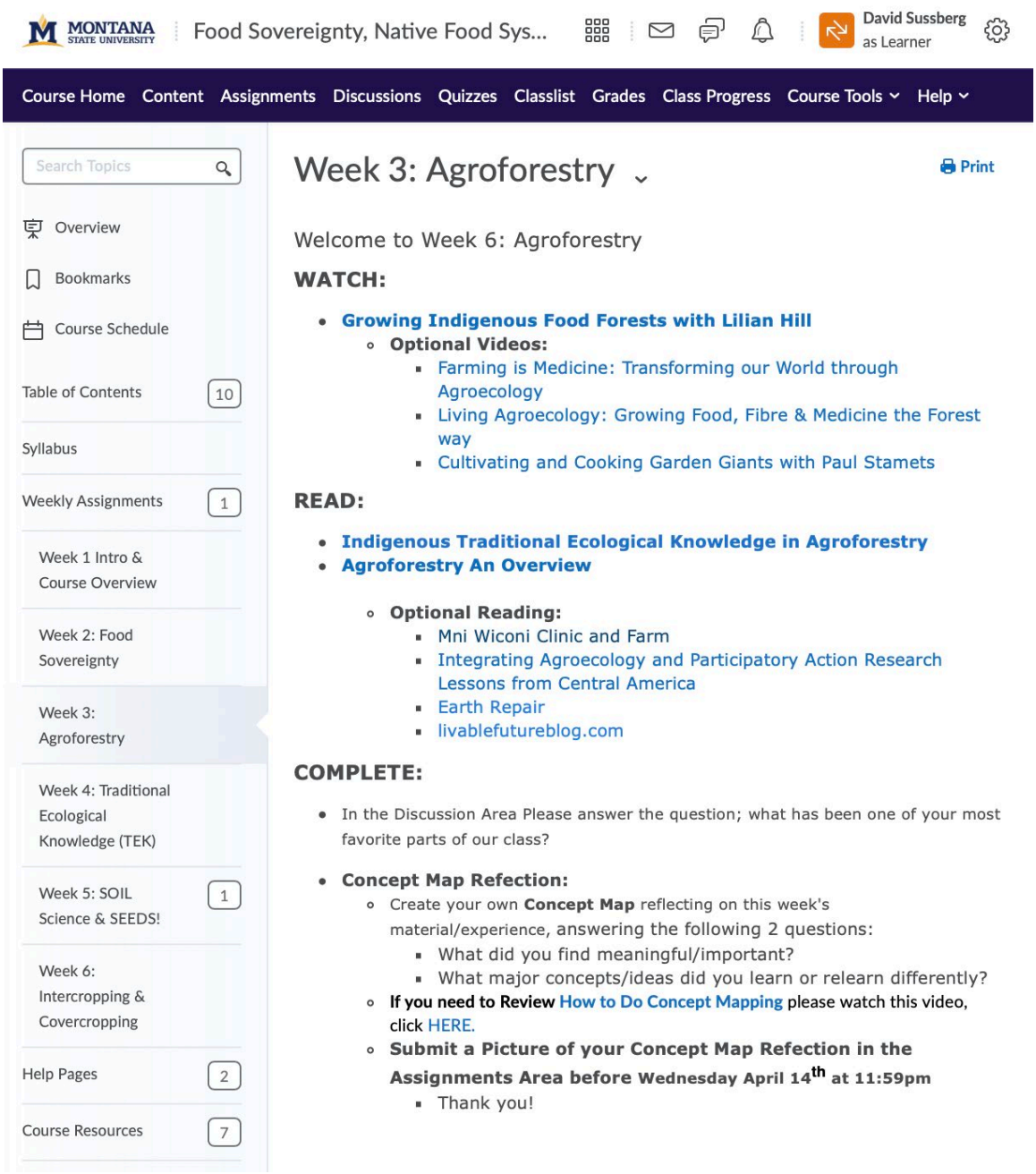


Figure 14. Screenshot of the Food Sovereignty, Native Food Systems, and Agroecology Brightspace (D2L) Course's Week 3: Agroforestry.

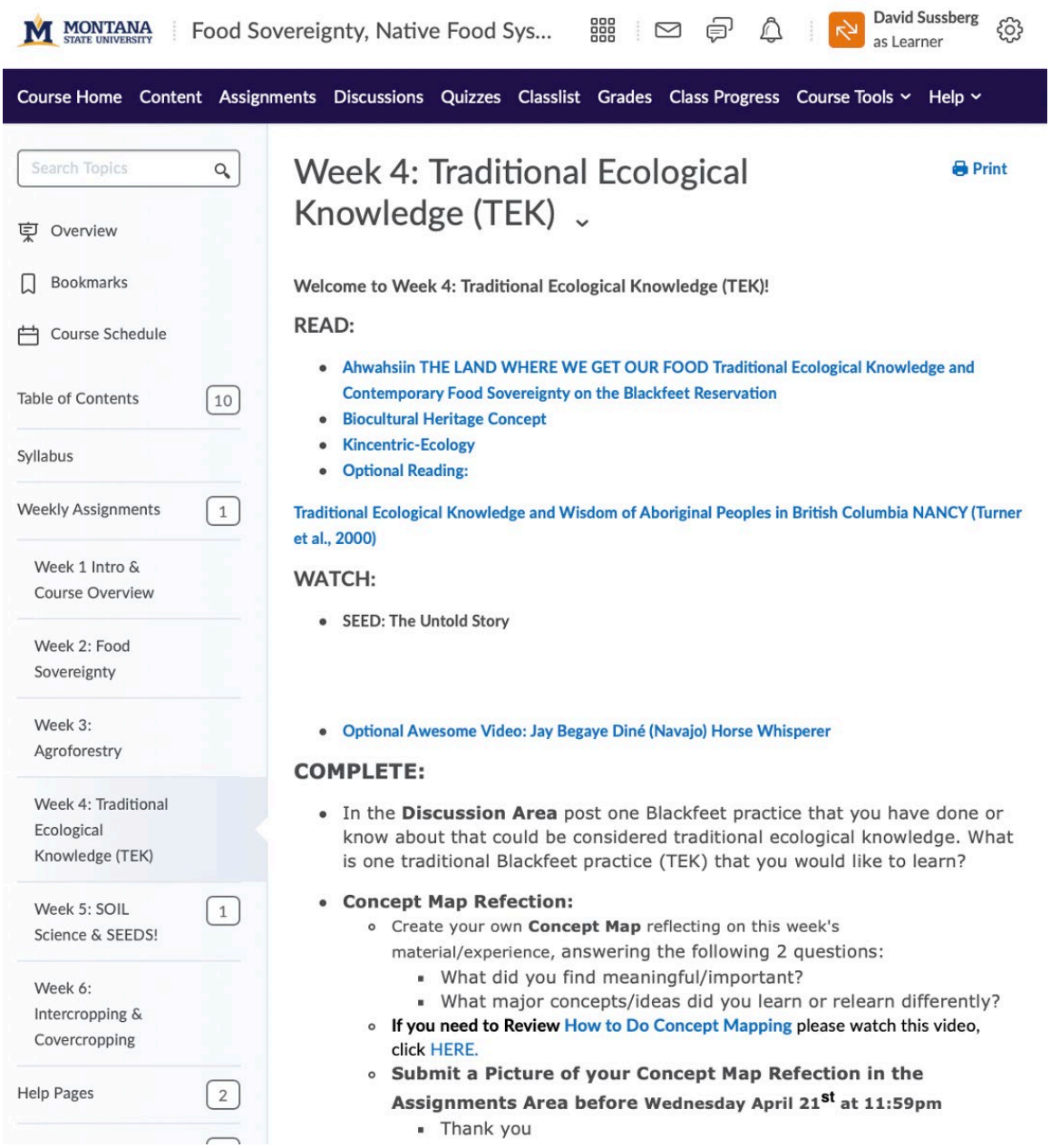
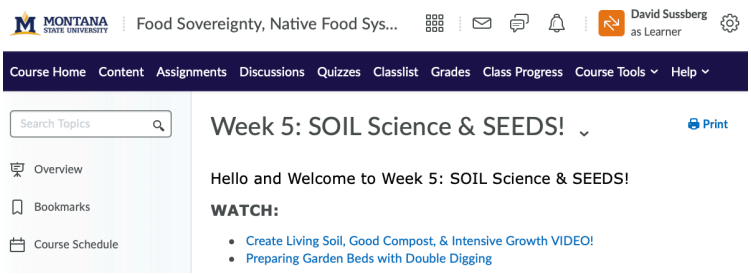


Figure 15. Screenshot of the Food Sovereignty, Native Food Systems, and Agroecology Brightspace (D2L) Course's Week 4: Traditional Ecological Knowledge (TEK).



- **Optional**, but **HIGHLY ENCOURAGED:**
  - **Indigenous Seedkeeping: Caring for our Three Sisters - with Rowen White**
  - Practical Knowledge Sharing with Indigenous Peoples Seeds
  - Indigenous Seed Keepers Network
- **Other Optional Videos:**
  - **Conventional vs. Organic Farming... Which One?**
  - **Regenerative Agriculture -- A Solution to Climate Change | Ben Dobson | TEDxHudson**
  - **How does Organic Farming Compare to Conventional Farming?**

READ:

- **Five Indigenous Farming Practices Enhancing Food Security**
- How Native Americans Are Fighting a Food Crisis
- Ethnomedical and Biodynamic, Agroecological Properties of Select Companion Plants in Traditional Milpas
- Intercropping also know as Companion Planting
  - **Optional Reading:**
    - Why SUPPORT NATIVE BEES
    - Intercropping for Benificial Insects
    - Read p.96-99 from: Intercropping Legumes with Nonlegumes (e.g., Cereals: Rye, Wheat, Oat, Barley, etc).
    - "Inagrative Pest Managment" Agroecology and the search for a truly sustainable agriculture
    - From Invisibility to Transparency: Identifying the Implications
    - Crop Rotation on Organic Farms A PLANNING MANUAL Charles L. Mohler & Sue Ellen Johnson, editors

EXPLORE:

- **Audio Podcast of Blackfeet Agriculture Resource Management Plan. Part 1**
- Can Organic Farming Feed the World... By David Sussberg1

COMPLETE:

- In the **Discussion Area** post one practice that you learned this week that could be utilized on the BCC's Farm.
- **Concept Map Refection**
  - Create your own **Concept Map** reflecting on this week's material/experience,answering the following 2 questions:
    - What did you find meaningful/important?
    - What major concepts/ideas did you learn or relearn differently?
  - **If you need to Review How to Do Concept Mapping** please watch this video, click HERE.
  - **Submit a Picture of your Concept Map Refection in the Assignments Area before Wednesday April 28th at 11:59pm**
    - Thank you!

Figure 16. Screenshot of the Food Sovereignty, Native Food Systems, and Agroecology Brightspace (D2L) Course's Week 5: Soil Science & Seeds.

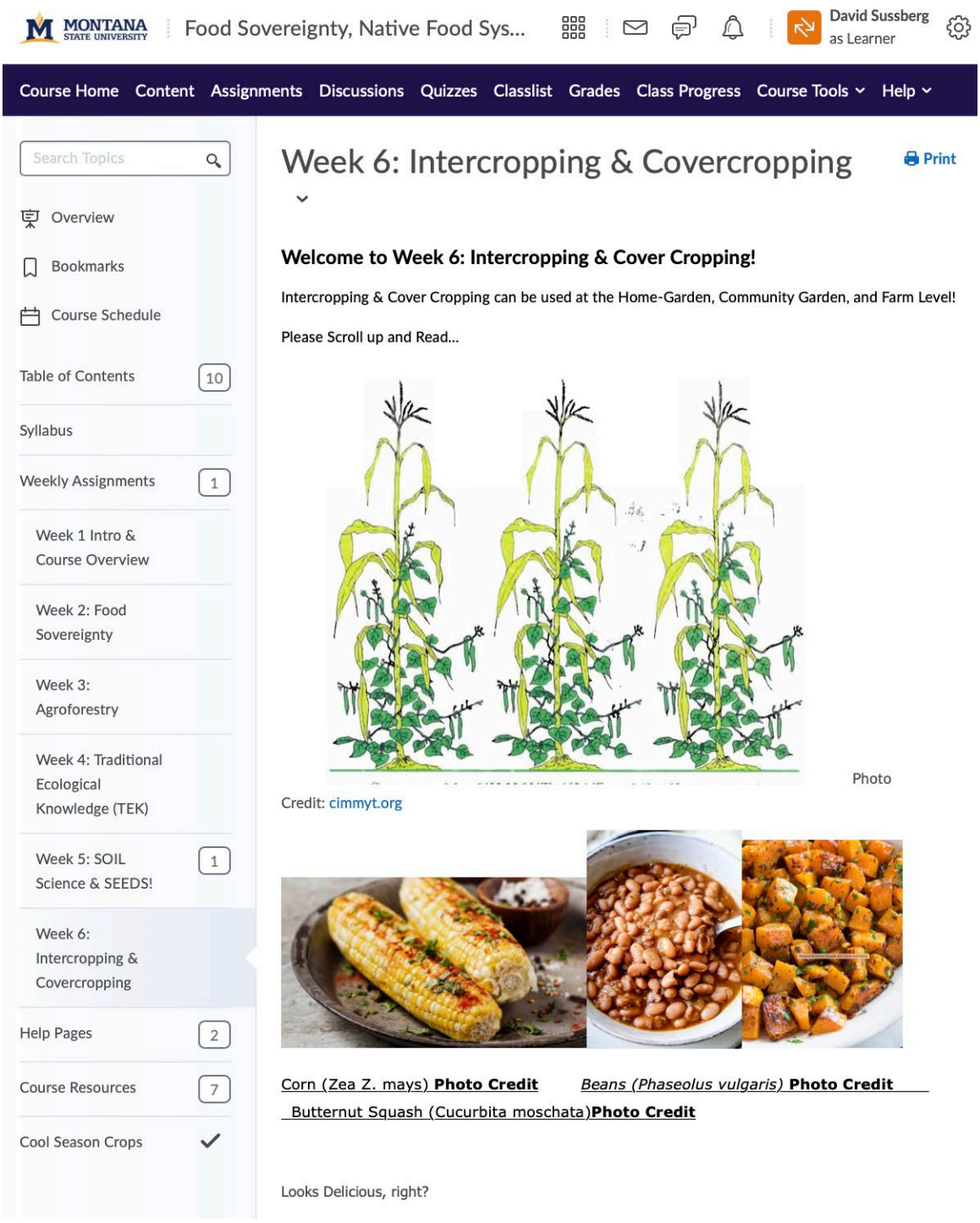


Figure 17. Screenshot of the Food Sovereignty, Native Food Systems, and Agroecology Brightspace (D2L) Course's Week 6: Intercropping & Cover cropping.

Please complete the following before Wedensday Midnight (Mountain Time):

WATCH:

- La Milpa (The 3 Sisters Farming System)
- Introduction to Cover Cropping
- Cover Cropping Talk
- **Optional Videos:**
  - How This Navajo Chef Brings His Native Food Traditions Back
  - Biocultural Crops and Traditional Farming - Dreaming New Mexico | Bioneers
  - One Awesome way to Grow Winter Squash... Vertically!
  - The Science Behind the Three Sisters
  - Oneida Corn Harvest
  - Food Security & Three Sisters Sustainability - Conversations in Cultural Fluency #3
  - How to Sow Carrot Seeds
  - Cover Cropping Talk and Q&A

READ:

- the difference between intercropping and companion planting
- Please note, **the following Reading is Incredibly Important** and you have this week and next week to read it, so start super soon:
  - **ON INTIMACY WITH SOILS Indigenous Agroecology and Biodynamics By DEVON G. PEÑA**
- Traditional Mayan Farming
- Covercropping & Intercropping
- Benefits of Cover Cropping
- **Optional Reading:**
  - Seeds and beyond: Native Americans embrace 'food sovereignty'
  - Four Ways Mexico's Indigenous Farmers Are Practicing the Agriculture of the Future
  - SQUASH Varieties + Health
  - The Principles of Agroecology
  - Chapter 1 Introduction: Agroecology as a Transdisciplinary, Participatory, and Action-oriented Approach
  - Towards an Alternative Development Paradigm Indigenous People's Self-Determined Development
  - Precursors of Decolonial Pedagogical Thinking in Latin America

EXPLORE:

- Audio Podcast of Blackfeet Agriculture Resource Management Plan. Part 2
- Cool Season Crops
- Environmental Factors Affecting Seed Germination

COMPLETE:

- In the **Discussion Area** Please post one Intercrop System that you believe would be important/appropriate to grow at BCC.

Figure 17. (Continued). Screenshot of the Food Sovereignty, Native Food Systems, and Agroecology Brightspace (D2L) Course's Week 6: Intercropping & Cover cropping.