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Sustainable Agriculture Curriculum For 9th-12th Graders

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SUSTAINABLE AGRICULTURE CURRICULUM FOR 9TH-12TH GRADERS

By

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DEDICATION

To my friends and family that gave me the motivation required to keep going even when I wanted to quit. To Marissa for spending two plane rides plus a few hours ripping my paper apart and finally thank you to my capstone committee. Your advice and support brought me to this point.

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CHAPTER ONE

Introduction

Overview

According to the NASA (2021) website the main cause of the climate crisis is the greenhouse effect caused by specific gases in our atmosphere. The agricultural industry is a leading producer of greenhouse gases. These gases are carbon dioxide, methane, nitrous oxide, and water vapor. Methane is naturally emitted by livestock; specifically, ruminating animals. Nitrous oxide is commonly produced from fertilizers and pesticides used to grow crops; and carbon dioxide is found in the emissions of all the farm machinery used to raise livestock and grow produce (NASA, 2021). Agricultural scientists are working hard to find alternative production methods that will reduce or eliminate agricultural greenhouse gas emissions completely. However, these methods are only useful if they are implemented, and implementation can only happen if there is support from the agricultural community in the United States and around the world. In order to gain that support, the new agricultural practices need to be sustainable for the environment and for the agricultural producer as well. One way to encourage the implementation of sustainable agriculture practices is to educate high school agricultural students about the relationship between climate change and food production.

For my capstone, I will identify the best resources for a sustainable agricultural curriculum that can be implemented in a 9th-12th grade agricultural class. In this paper I will emphasize the dangers of climate change, highlight the sustainable agricultural practices that could be implemented, justify why this curriculum should be implemented

with high school students by agricultural educators, and identify the best pedagogical practices to implement the curriculum.

Why Climate Change

Growing up in central Minnesota has given me the opportunity to see climate change in action. Minnesota has four distinct seasons that are relatively predictable. The three months of Summer are hot and humid, with a storm every few weeks. Fall begins around September with day time temperatures in the seventies and night time temperatures in the fifties. By Halloween day time temperatures are in the fifties and costumes require a Winter coat. November through February is typically full of snow and temperatures as cold as twenty below zero. Thick sheets of ice form on all of the lakes. Spring sneaks in with random warm days in March and at least one to two snow storms in April. Most of the snow and ice have melted by the middle of May, which indicates a start to the hot summer in June. However, as I have grown, this predictable cycle I remember as a child has disappeared. It seems every year we get less snow, and it arrives later in the year. Many years I wonder if Minnesota will have a white Christmas or if it will just be the sad brown left over by Fall. As an adult, I no longer just observe the seasons; but I can track the data collected by people like Mark Sealy, the Minnesota Public Radio meteorologist.

The data is easy to read; Minnesota, and the rest of the world is getting warmer. This warming is leading to some areas of the globe getting more precipitation, while others are becoming much drier. By 2015 a majority of Minnesota had a 5-15% increase in rainfall since the 1960's (MPR, 2015). The effect that these changes have on Minnesota are varied and worrying. According to an article by the Environmental

Protection Agency (2016), the makeup of our northern forests are shifting from Spruce and aspen to maple as the weather is less hospitable to our cold weather adapted trees. This shift in the ecosystem results in a shift of wildlife populations as well. Birds are traveling further north, and moose are becoming less common in their once regular habitats. Ticks that carry Lyme's disease are becoming more common and widespread. The ragweed allergy season has also increased by as much as 25 days in certain regions of Minnesota. These changes in Minnesota are echoed around the world.

California is experiencing severe drought and potentially drinking water shortages (Fritz, 2021). Ice sheets in Antarctica are melting at an alarming rate causing sea levels to rise, and some areas of the world are experiencing record setting temperatures for several days in a row. An increase of water vapor in the atmosphere can be linked to more severe weather events (Fritz, 2021). Climate change is slowly but surely having a larger impact on our daily lives. One example of how climate change is affecting our daily lives is the impact it is having on the agriculture industry.

Agriculture impacted by climate change

The agricultural industry is particularly vulnerable to the effects of global warming. Changes in predictable weather patterns, growing seasons, and access to water can devastate farmers' ability to produce food. An example of this is the Derecho that went through southern Iowa on August 10th of 2020. The storm produced hurricane force winds, flattened nearly 10 million acres of corn and blew away thousands of dollars of stored crops. While the storm itself cannot be directly linked to climate change, the increase in severity of the storm can be linked to an increase of water vapor in the air. That increase of water vapor can be linked to the effects of global warming.

In addition to an increase of water vapor in the atmosphere, the increased temperatures cause more evaporation, making fresh water harder to obtain. The agricultural industry accounts for approximately 70 percent of all freshwater consumption in the United States. A dairy cow needs to drink 15-30 gallons of water a day, and around 1,800 gallons of water are required to produce the cotton for one pair of blue jeans (Water, 2020). Climate change creates less predictable weather, which makes growing and raising food a much larger challenge. In Minnesota, there is always a rush to get into the field to plant the growing season's crops. If the land is too saturated in the spring, driving equipment on fields can lead to impaction of the soil. Planting too late means crops have to compete with weeds for water and nutrients. To manage those weeds farmers will either need to spray herbicides, till, or see a decrease in their fields yield. Additionally, the lack of traditionally cold winters has led to pests and diseases surviving winter to infest another year's crop. Agricultural crops are not the only thing affected; livestock is also at risk.

Another aspect of agriculture affected by climate change is livestock production. Animals, similar to humans, are sensitive to weather extremes. Extreme temperatures cause livestock stress, which often leads to disease or death. In order to control factors like temperature, farmers would need to build a facility large enough to house all of their livestock. However, this can be prohibitively expensive and energy intensive to build and maintain. Animal welfare also raises concerns about the ethics of keeping livestock completely indoors. Concerned consumers will pay more for organic, cage free, or grass fed beef that certifies the animals had access to the outdoors. The concern for animal welfare will often get mixed in with consumers beliefs about how healthy a product is to

consume. Resulting in traditional methods of raising livestock indoors being seen as less healthy than eating products from alternative methods.

Agricultural practices and their effect on climate change

Despite growing up in a small rural community, my family was disconnected from the agriculture community until I joined the national FFA organization in high school. Joining the student organization opened my eyes to the way food is produced in the United States. Practices that once seemed cruel to me, for example the utilization of farrowing stalls, made sense when seeing them utilized at the CHS Miracle of Birth Center at the Minnesota State Fair. The sow would frequently lay down on top of the piglets. Unlike a human, cat or dog, the sow did not get up when the piglets squealed in pain. Instead, the Sow would continue to crush the piglet until it either escaped or died. I came to realize that farrowing stalls helped decrease the mortality rate of piglets because the piglets had a protected area where the sow could not directly lay on them. These experiences led me to choose a career as a high school agriculture instructor. The amount of information I was illiterate to in the agriculture industry was surprising and which caused me to become passionate about educating people about the subject.

The history behind how and why we use certain practices in agriculture dates back to the first seeds planted. Throughout this research paper, we will discuss how agriculture went from being small subsistence farming to massive farms that feed hundreds of thousands of people. One of the biggest advancements in agriculture was the creation of the engine. Tractors allowed farmers to cultivate many more acres of land, trucks allowed us to transport goods much further before they expired. Refrigeration expanded our ability to reduce spoilage and ship food. Farms became specialized on

specific crops and animals versus the general productions of the past. As these farms grew, many farmers were unable to keep up with the changes or chose to pursue different careers now that they did not have to produce their own food. According to Public (2020) The green revolution spearheaded by Norman Borlaug opened the door to more precise breeding techniques in crops and allowed farmers to take advantage of the new synthetic fertilizers, pesticides, and herbicides. The yield from a single acre of crops grew massively and farms became much more efficient. Livestock also became much more efficient and specialized. Milk parlors allowed farmers to produce milk at a much faster and much larger rate, specialized feed rations allowed livestock to produce more meat with less feed. These technological leaps lead us to 21st century agriculture.

Agricultural production today is very specialized, and less than one percent of the population feeds our country. One US farmer feeds approximately 166 people versus the 1900's where one farm fed around 10 people (FB). Farmers have increased their production while reducing their inputs for years. Yet there is a lot of work left to do.

The world population is expected to hit 9 billion by 2050, and scientists estimate that farmers will need to produce 70% more food a year than they are producing now. This will have to be on less land, with less water, and a massive reduction in greenhouse gas emissions. Thankfully, many new technologies are making this future possible. Genetic modification, hydroponics, robotics, and precision technology is allowing farmers to become much more efficient and reduce their impact on the environment while growing more food. These practices and more are what I will be exploring and turning into a curriculum for agriculture students.

Implementation of Curriculum

As previously stated, I was introduced to the agricultural industry as a freshman in high school through my school's FFA program and agricultural classes. Agriculture education has been around since 1917 with the Smith-Hughes act that introduced vocational classes into schools. I chose to go into agriculture education because of the impact my agriculture experience program had on me.

I have also found that the agricultural community often feels threatened by the push for different agricultural practices. This is often because the legislation or rhetoric around the legislation often makes farmers out to be villains or it changes practices in a way that would be financially unsustainable for farmers. An example of this I have seen is the rhetoric around the green new deal, which was accused of banning beef. An actual read through of this resolution shows that is not the case, but any legislation related to the green new deal will be tainted in most farmers minds. In general, I have seen great resistance from the agricultural community being told to change by sources outside of themselves. For this reason, I believe agriculture educators would be a great source for teaching about sustainable agriculture.

The curriculum taught in agriculture classes is varied due to the wide variety of class topics taught. The curriculum I will create for this class would be for an introductory agricultural class. It would also contain lessons that could be taught individually in plant science, animal science, and even agriculture shop classes like small gas engines or welding. By creating this curriculum, it will be much easier for agricultural educators to include conversations on climate change without it becoming a politically controversial conversation in the classroom.

Summary

Climate change is a threat to nearly every aspect of our lives. For this reason we need to do all that we can to reduce or even eliminate its effects. In order to do that we need to address the current practices that are contributing to the overall problem. The agricultural industry is posed with the challenging issues of producing enough food for the growing population while reducing their greenhouse gas inputs. In order to do this, consumers and future agricultural professionals need to be made aware of the developing technologies that can meet this goal. My role as a high school agricultural teacher allows me the opportunity to inform my students on these issues.

This paper will focus on creating a curriculum that educates high school students about more sustainable agriculture practices and how they can be implemented at farms. By presenting this information from educators that are considered a part of the agricultural community, the practices are more likely to be implemented instead of brushed off as a political point. In the next chapter of this paper I will complete a literature review of current and developing agricultural practices that are more sustainable for the environment, and then utilize this research to create a sustainable agriculture curriculum that can be implemented by agricultural educators.

CHAPTER TWO

Literature Review

Overview

In this chapter, we will examine the literature on climate change, agriculture, and educational strategies in order to create a 9-12 grade sustainable agriculture curriculum that teaches students about sustainable agriculture practices. In order to successfully teach a sustainable agricultural curriculum, this chapter will analyze different instructional strategies to determine what the best method of conveying this information to students will be. Additionally, different assessment methods will be reviewed and to identify and implement a diverse way for students to show what they have learned from this curriculum. Finally, we will identify the scientific studies that show how climate change is affecting the planet, and specifically what impact it will have on agriculture. Mitigation strategies will also be discussed and identified so that they can be incorporated into the curriculum.

Increasing students' knowledge of climate change, its causes, and its effects will make our public more willing to make the necessary changes to mitigate and adapt to climate change. Specifically, this paper will examine the way that increasing temperatures will change the availability of freshwater, increase the likelihood of diseases, pests, and weeds, and cause reproductive issues for plants. It will also highlight how the livestock industry is and will be affected by climate change.

Implementation of Curriculum

Environmental Education and Schools According to a workshop summary written by A. S. Betty (2012), the following goals have been identified by climate

educators as the benchmark for understanding climate change in k-14 student populations:

- Fundamental processes that influence climate, at scales ranging from local to regional to global.
- Natural variability and natural cycles in climate
- Human impact on the climate-that is how the growth in human population and technology has made it possible for human activities to change in climate patterns at various scales.
- How changes in climate can and do influence physical systems, ecosystems, and society.
- Why the scientific community is now convinced that anthropogenic climate change is underway.
- What the range of effects of climate change is and how likely various different scenarios of climate are under different conditions. (p.5)

The purpose of these goals is to not only prepare students to go into a scientific field that deals with climate change, but to prepare them to vote on policies addressing climate change and to make informed personal decisions about how to address climate change in the future. Research has found that students retain and act on the information more frequently if they are exposed to it at multiple grade levels. In addition to preparing students to make informed decisions on climate change, the sustainable agricultural curriculum will be used to develop skills that will make them productive citizens.

Fazio (2013) states that schools around the world have been implementing policies and environmental education programs since the discovery of the environmental

crisis in the 1970's. The specific purpose of these programs is to help students understand relationships between humans and the environment, ecological patterns, and develop the skills of critical thinking, empathy, and creativity. In the workshop reflection written by Beatty in 2012 it claims the curriculum that has been developed for environmental education re-enforces mandatory science standards. Minner (2010) identifies that a hands-on approach to learning increases engagement and motivation for students. This strategy combined with Fazio's findings in 2013 that a common approach to implementing an environmental education curriculum is to focus on local environmental issues, allows the students to put scientific theories into practice and it builds relationships between the school and the community. For these reasons the sustainable agricultural curriculum that will be developed for this project will utilize a hands-on approach to engage students with the material.

Curriculum Design

Project based learning is a term used to describe a series of complex projects used to teach students Science, Technology, Engineering, and Math concepts, commonly referred to as STEM (Capraro, 2013). Studies show that project based learning is highly engaging and allows students to develop their critical, analytical, and higher-level thinking skills. Capraro also states that the skills and concepts learned in project based learning allow students to use multiple areas of knowledge to solve real world problems. For the sustainable agriculture curriculum, the real world problem will be addressing climate change and how it affects agriculture.

The next section of this paper will identify the scientific studies that prove climate change is a problem that will affect multiple areas of the planet. The literature will

discuss how climate change was identified, the evolution of scientists' understanding of how climate change will affect the planet and the different mitigation and adaptation strategies that are being proposed and implemented. This research will be used as a foundation for the 9-12th grade sustainable agriculture curriculum project.

Climate Change and Agriculture

Introduction

Earth has gone through many climatic changes in its lifetime which directly correlate to the amount of carbon dioxide in the atmosphere, from the ice ages to tropical ecosystems at our North and South poles (May, 2008). According to May (2008) the stabilization of the global climate and carbon levels in the atmosphere, approximately 280 ppm, has lasted for the last 8,000 years. May (2008) also identifies stabilization as one of the driving factors behind the invention of agriculture, and civilization. His book (p. vii) shows that the industrial revolution resulted in an increase in the amount of carbon dioxide in the atmosphere, from 330 ppm in the mid 1970s to 380 PP in 2008. Groups like the Intergovernmental Panel on Climate Change have predicted that we will reach nearly 500 ppm by the year 2050, which could result in a global rise of world temperatures by 2° Celsius. A 2° Celsius increase in global temperatures will result in a variety of changes to the world's biogeochemical cycles that will have long lasting effects around the world. If we do not manage to contain our carbon emissions to 500 ppm, there will be devastating consequences for life on earth.

General Effects of Climate Change

The specific impact of climate change is an increase in the average global surface temperature around the world. This change will vary depending on different regions of

the globe, with the largest impact being at the poles (Kaplan, 2006). The following results of the study conducted by Jed O. Kaplan and Mark New (2006) shows how the Arctic will be impacted by higher temperatures:

> The geography of the Arctic (land-sea distribution) and snow/ice albedo feedbacks, along with changes in cloud and ocean heat transport, lead to an amplified regional warming over the Arctic that ranges from between 3.2 and 6.6 ◦C for a global change of +2 ◦C. In each of the GCMs (Global Climate Models) that were evaluated, the amplification is similar for fast and slow warming scenarios, so changes in the Arctic predicted by a single model will be comparable regardless of when a global change of +2 ◦C occurs. (p. 236)

Kaplans (2006) paper states that this level of warming would likely result in the melting of permafrost soils, which would release more methane into the atmosphere. The ecosystems found in the arctic would be disrupted and scientists would expect to see shifts in the foliage and wildlife that live in the area. The disruption to the arctic would increase precipitation levels and ultimately increase sea level.

An increase in sea level is another dangerous effect of climate change. Sea levels have increased by 20 centimeters in the last 100 years (Patz, 2014). Patz found that sea levels are expected to rise between 26 and 98 cm in the next eighty years, with a worst case scenario of around 200 cm. Javeline (2019) found that an increase in sea level could result in large-scale infrastructure damage and the salinization of water tables, these damages could make popular coastal areas uninhabitable. The cost of repairing these areas will continue to increase so he believes that adaptation to these changes need to begin sooner than later.

In addition to sea levels rising, Patz (2014) states that the world can expect to see a change to weather patterns. Some areas of the globe will experience more precipitation while others will experience more drought. Patz identifies these weather changes as being linked to an increase in extreme weather events such as severe droughts, wildfires, and more intense hurricanes and floods (Patz, 2014). An increase in extreme weather events will affect human health in a variety of ways including an increase in mental health disorders, heat related disorders, respiratory issues, and infectious disease (Patz, 2014). Extreme weather events are also expected to impact agricultural production, which he believes will make our food system less reliable.

The information identified above shows the importance of educating people about the danger of climate change. While sustainability is being pursued by the agricultural and other industries, there is still debate about the validity of climate change (Taylor, 2018). A study conducted on Floridians by Taylor et al., 2018, found that 75 percent of the participants agreed that climate change existed and was ongoing. Despite the majority of responders acknowledging the dangers of climate change, multiple public leaders in the state were vocally opposed to climate change mitigation policies. Taylors paper indicates that researches suggest that agricultural educators should work to improve both citizens and politicians' understanding of agriculture, food and natural resources. With this in mind, the approach to teaching the sustainable agriculture curriculum needs to allow room for students to develop their own opinions on climate change. It is important that the teacher is not seen as pushing their own view on students for political reasons. For this reason the sustainable agricultural curriculum will identify the science behind the ongoing increase in the average global temperature and changes to weather patterns.

Causes of Climate change

Philander (2012) explains that global warming and cooling is a natural part of earth's history and there are multiple factors that go into the changing of the planet's overall temperature. Philander (2012) identifies that the science of prediction is never certain, which allows room for climate change deniers to argue that the warming data scientists are seeing is a result of a natural process. However he refutes the deniers by identifying how scientists have been measuring carbon dioxide levels regularly since 1958, and have been able to analyze carbon dioxide trapped in ancient ice sheets to identify the historic carbon dioxide levels (Philander, 2012).

A study conducted by McNall (2011) states that scientists have observed an upward trend of carbon dioxide and global temperatures that correlates with the amount of fossil fuels burned by humans. According to McNall, scientists are also able to analyze the radioisotopic fingerprint to identify where the carbon came from and therefore match it to the carbon released from burning fossil fuels. To understand this relationship better, one can look at the carbon cycle. Loustay (2012) describes how carbon dioxide in the atmosphere is utilized by plants during the photosynthesis process to make sugar. That sugar in the form of cellulose, or other plant material is frequently eaten by animals who breathe out the carbon dioxide and use carbon in their biological structures. The article states that when plants or animals die, the carbon inside them is stored in the soil as they decay. Fossil fuels are made up of this decayed material and when it is burned the fossil fuel releases the carbon dioxide back into the atmosphere. Philander identifies the oceans and biomasses inability to pull the excess carbon dioxide from the atmosphere, as the

disruption of the natural carbon cycle, which in turns interrupts many other natural cycles.

Research conducted by May in (2008) explains why the second most potent greenhouse gas is methane (CH_4). Methane is found in much smaller concentrations in the atmosphere than carbon dioxide, so much so that it is measured in parts per billion versus parts per million. However, methane absorbs more energy than a carbon dioxide molecule. It is the second most worrisome greenhouse gas because it has a much shorter lifespan in the atmosphere compared to carbon dioxide. Typically it will be in the atmosphere for around ten years, verus carbon dioxide which can last up to a few hundred years. Pre Industrial revolution levels of methane were around 700 ppb and have risen to around 1770 ppb. Methane is produced through rice cultivation, livestock production, burning of coal, natural gas, or biomass, and it is one of the gasses released by landfills as the organic waste decomposes. As mentioned above, methane does not stay in the atmosphere for long, in the troposphere methane reacts with a hydroxyl molecule (HO-) to create carbon dioxide (CO_2) and Water Vapor (H_2O). When methane rises to the stratosphere it is destroyed.

May also identified other contributors to climate change and global warming in his study; include ozone gasses (O_3), nitrous oxide (N_2O), fluorinated gasses, and aerosols. While some of these gases, such as nitrous oxide can be linked to natural processes, others can only be linked to industrial processes. These pollutants act similarly to carbon dioxide and methane in the way that they absorb and reflect solar radiation. While greenhouse gases are the main contributors to climate change, there are a number of other variables that play a role. Deforestation, soil degradation, and habitat loss are all

additional contributors to the greenhouse effect. Their role can be more or less direct at times, but due to the fact that earth has many cycles that depended upon one another, disruption to one seems to affect all of them over time (McNall, 2011). In order to fight climate change, we need to have a multifaceted approach that targets the biggest contributors first. The 9-12th grade sustainable agriculture curriculum will be one tool for addressing these issues.

Strategies for adaptation and mitigation

According to Pollin (2019), there are many factors that contribute to climate change, with the largest one being the burning of fossil fuels such as coal, natural gas, and oil. The seemingly obvious answer is to switch to other energy sources. There is also a pressing time issue, in 2007 the Intergovernmental Panel on Climate Change identified specific actions to keep global warming below two degree celsius. The first step was to reduce global emissions by 40 percent in the first twenty years. Secondary global emissions would need to be reduced by 80 percent by 2050. Pollin (2019) shares that global emissions have actually risen by 43 percent. In order to reduce greenhouse gases in the atmosphere, nations around the globe will need to cut their use of fossil fuels. However, this is much easier said than done. Both rich and developing nations are highly dependent on fossil fuels. Despite the fact that the majority of the carbon in the atmosphere was produced by developed countries, all nations must bear the burden of mitigation (Pollin, 2019). He explains that the transition to energy sources that do not add carbon to the atmosphere can be very expensive and out of reach of poor or developing nations. In democratic countries, educating people about the strategies for

responding to climate change can help ensure that the voting populace is willing to support the societal shifts that may need to take place.

Research conducted by Rickinson, Kollmuss and Agyeman highlights the need for environmental education and explains how education changes behavior towards and feelings about the environment (Lundholm, 2019). Lundholm's (2019) studies showed a continued need for environmental education work. Their paper identified a paradox when trying to convince people to make changes that are good for the environment (Lundholm, 2019). According to Lundhom (2019) most people do not voluntarily make those changes without knowing that others are making similar changes, paradoxically in order for everyone to make equal changes it requires an authority like the government, which is representing the views of people that are conservative about making changes. Lundholm's (2019)studies show that one way to address this paradox is through education that focuses on how pollution is created and how we can clean it up versus just focusing on the sciences behind environmental systems and the effects of degradation. When given the context around the pollution, learners are more likely to make changes and support policies that lead to a healthier environment.

Climate Change and Agriculture

Overview

Agriculture is generally thought to have risen out of the fertile crescent in what is today the middle east (Ziska, 2017). Despite it being much more labor intensive than hunting and gathering, many groups took up agriculture as a way of life. This is thought to be because agriculture produced enough food to allow some people to not have to worry about producing food. Thus rose cities and hierarchical societies that had a variety

of roles in society. However, Ziska's book states that agriculture did not spread through the world because it was a superior technology, instead it is thought to have spread thanks to disease and disease resistance. Dense populations of people in the same place as high populations of livestock lead to many zoonotic diseases. People in cities being exposed to these diseases meant they built up an immunity; whereas hunter gathering groups did not have the same advantage. This eventually led to the hunting-gathering societies dying out.

Ziska (2017) states that a study of history shows a direct link between the downfall of a society and a severe disruption of its food supply. Famine was the start of severe social unrest that led to the collapses of societies in Rome, Ireland and China. A quote from Lewis H Ziska (p. 16), does a great job of summarizing this idea; "Concentrated populations only exist because of the ability of agriculture to produce the necessary food. Consequently, when such food is not available famine occurs and civilizations fail." When examining what causes famine, it is often found that it is not simply a lack of food, but a lack of affordable food. As recently as the 1970's, scientists and philosophers were predicting a global wide famine that would cost millions of lives. According to Ziska's book, it was only the invention of two technologies that prevented the global famine.

Ziska credits Fritz Haber's discovery on the synthesis of atmospheric nitrogen as one of the main reasons the global famine was avoided. With this discovery, nitrogen fertilizer, one of the three most essential elements to plant growth, became widely available. The second preventative technology was a new plant breeding technique discovered by Norman Borlaug, allowing countries like China, India, and Mexico to go

from importers of grains to exporters in less than ten years. These processes combined raised the world's grain production by nearly 200 percent per acre, and Ziska believed it made today's global society possible. However, he also recognized that these technologies have limitations. The world's population is predicted to grow to around 9 billion people by the year 2050. The increase in population will require an increase in food production by approximately 70 percent (Ziska, 2017). This increase in demand combined with the challenges that climate change poses makes food security in our future questionable.

Plant Science

Our entire food system is based upon eight different grains which provide around 70 percent of global calories (Ziska, 2017). Rice and wheat are the two largest contributors making up nearly 50 percent of the calories consumed (Ziksa, 2017). Despite the benefits of the green revolution, they came with consequences as well. Jewitt (2015) identifies one of the consequences as being the process to pull nitrogen from the air requiring a massive amount of energy, which currently comes from the burning of fossil fuels. As previously stated, in order to stop climate change, burning fossil fuels needs to stop. A second consequence of the green revolution is identified by Ziska; that the dwarfed, more fertilized crop varieties required more water. Farmers used wells for irrigation, which has depleted available groundwater. As climate change causes some areas to be drier, Ziska believes there is a real fear of completely depleting aquifers.

Another consequence of the green revolution was that because crops were shorter, they had a harder time out competing weeds for resources (Jewitt, 2015). According to

Jewitt, this meant that farmers turned to chemical pesticides and herbicides to help get rid of the weeds. When overused the chemicals runoff into rivers and leach through the soil into groundwater, putting both wildlife and humans at risk.

Philander (2012) shares that fossil fuel companies believed a benefit of climate change was that plants would thrive due to the increased production of carbon dioxide, which is a main ingredient in photosynthesis. However, research shared in Ziska's (2017) book shows that while carbon dioxide is beneficial to crops, it is even more beneficial to weeds and invasive species. Ziska (2017) believes that this will likely cause an increase in the need for herbicides. Farmers that cannot afford the agrochemicals necessary to keep up with the weeds, will see a decrease in their crop yields.

Another vulnerability identified by Ziska is that crops face increased heat. Plants like humans are sensitive to specific sets of temperatures. While climate change could be beneficial to northern farms due to the increase in growing season, dry and hot areas could become too hot to produce many foods. In order to produce a fruit, a flower must be fertilized by a pollen grain. Many plants will fail to produce fertile pollen if they are exposed to too hot of temperatures. For corn, wheat, and rice, temperatures over 35 degrees celsius or 102 degrees Fahrenheit can cause the flowering to fail. Inorder to cool themselves off, plants transpirat which is much like sweating for humans. Too much carbon dioxide will cause the stomatos that plants transpirate through to be much smaller. Transpiration also becomes much more difficult when the air is too humid due to the fact that the atmosphere will not absorb the moisture from the plants. These plants are also dependent upon pollinators to multiply which have also been impacted

by climate change. Pollinators like the honey bee rely on the protein they gather from eating flower nectar. Increasing carbon dioxide levels reduces the amount of protein in a flower, which contributes to the loss of our pollinators.

Land change is another contributing factor to climate change that is frequently caused by agriculture (Philander, 2012). Philander explains that in some areas of the world where farmers have little access to the fertilizers required to keep soil healthy, they use a practice known as slash and burn. In order to plant crops on healthy nutrient laden soils, farmers will cut and burn portions of the rainforest, forests, or prairies to clear it for their fields (Philander, 2012). Not only does this practice release carbon dioxide into the atmosphere from the burning of trees, it reduces biomass areas like the rainforest which acts as a massive carbon sink (Philander, 2012). The benefits for the farmer last only a few years due to the depletion of nutrients from the soil. Yields shrink and the farmer is forced to move their field into new fertile soil (Philander, 2012).

Ziska (2017) states that hot and warm conditions that are likely to be produced by climate change are optimal environments for fungi, bacteria, and viruses. According to Ziska (2017), Approximately 10-16 percent of global yields are lost to plant disease each year. Some plant diseases like potato blight and rust do well in moderate winters (Ziska, 2017). The warming of areas that are currently very cold in the winter may allow these diseases to occur more frequently and be more prolific in its spread. However, Ziska (2017) does state that higher temperature in already hot areas may help prevent the spread of disease. Ziska (2017) believes time will tell whether crops will have a net gain or loss due to plant diseases as climate change advances.

Application

Many of the effects of climate change on agriculture can be tested in the classroom with hands-on projects and labs. Inquiry based learning is a term used to describe the utilization of hands-on tasks and labs to increase engagement and motivation of students (Minner, 2010). The National Research Council's National Science Education Standards place an emphasis on inquiry based learning versus the memorization of facts and statistics. According to Orneck (2014) this approach to teaching fosters students' interest in learning and allows students to retain scientific concepts that can be applied to different situations. Inquiry based learning is able to do this by focusing on a scientific question, collecting data using a scientific process that allows students to collect evidence of the concept (Minner, 2010). Once the evidence is collected students are able to evaluate their evidence, compare it to their peers and determine what was supposed to happen and find reasons for any alternative results.

Orneck (2014) writes in his paper that students need to be able to replace their old concept in order to fully integrate a new concept. He identifies concept mapping as a tool to help students do this. Concept mapping provides a visual representation of all the steps that are supposed to take place and they can be a useful tool for assessing students' learning. In the sustainable agricultural curriculum concept maps will be utilized in conjunction with project based learning to show students the causes and effects of the relationship between climate change and agriculture.

Animal Science

Livestock production is another contributing factor to climate change. According to Grossi (2019), approximately 14.5 percent of greenhouse gas emissions come from

livestock production. Scientists predict that as the population increases and more developing countries become wealthier, demand for animal products will increase. Grossi (2019) believes that the largest threat that livestock production has on climate change is the amount of Methane and Nitrous oxide that is produced. Methane is mainly produced from fermenting manure which is frequently stored in large pits on farms (Grossi, 2019). Nitrous oxide is also produced by manure, and is common in organic and inorganic fertilizers (Grossi, 2019). According to Grossi (2019) the largest portion of greenhouse gas emissions comes from growing feedstuff for livestock; fuels utilized to produce the fertilizers, pesticides, and herbicides in addition to the fuels required by all the agricultural equipment. The transportation and processing of livestock products is another large emmitered of the greenhouse gas emissions contributing to livestock production (Grossi, 2019).

Grossi's paper explains that ruminant animals digest cellulose and convert it into volatile fatty acids through a process called enteric fermentation. This happens due to the unique digestive tracts of ruminant animals (Grossi, 2019). Grossi instead of a single stomach which is found in monogastric animals like humans and pigs, ruminant digestive tracts have four chambers to their stomachs. The first chamber of the stomach is called the rumin (Grossi, 2019). The rumin contains bacteria and other microorganisms that break down cellulose through fermentation. During the fermentation processes gaseous methane and carbon dioxide is produced which is expelled from the animal as a burp (Grossi, 2019). The amount of methane produced changes based upon the feed formulation and how easily the feedstuff is digested

(Grossi, 2019). Cattle and sheep are the largest producers of enteric methane, with beef production contributing the most to overall greenhouse gas production (Grossi, 2019).

Another threat that climate changes exacerbate in the livestock industry is the prevalence of disease which is identified in Ziskas book Our Daily Bread, published in 2017. Modern livestock production is based upon large concentrations of animals that are often in the same building. Due to the close proximity, disease can spread very quickly in a barn. In January of 2015, avian influenza (H5N2) spread through the poultry industry. It killed 50 million birds by June. According to a study conducted by Çakır, in 2018 the disease spread across fourteen states but four were hit especially hard. Minnesota, Iowa, Wisconsin and South Dakota. The avian pandemic hit the turkey industry particularly hard, costing around 225 million dollars, the majority of which was in exports.

An increase in disease in animals could translate to an increase in deadly human diseases. Pathogens that are transferred between humans and animals are known as zoonotic diseases. There are around 200 known zoonotic diseases, lymes disease and malaria are prevalent zoonotic diseases in society (Ziska, 2017). The ongoing pandemic Coronavirus disease 2019 (COVID-19) is thought to have spread from a bat that was likely sold at a wet market in China (Sheikh, 2020). According to Wildlife Trade, Covid-19, and Other Zoonotic Disease written by Sheikh and O'Regan (2020, p. 1) "Most emerging infectious diseases (EIDs) originated in animals and involve interactions between wildlife, livestock and people." These emerging diseases are most frequently occuring in areas where humans have altered native ecosystems and are in closer contact with wildlife (Sheikh, 2020).

Addressing Climate change with Sustainable Agriculture

An article written by Janssens in 2020 shares that in 2017 around 11precent of the world's population (821 million people) suffer from hunger. The areas of the globe most affected by hunger are sub-Saharan Africa, the Caribbean, and Southern Asian. Ziska (2017) shares that a change in weather patterns, an increase in the severity of extreme weather events, and a change in the amount of fresh accessible water will be immensely challenging for the agricultural industry. As a result, food production is likely to decrease and as a result, food prices are likely to increase. According to Janssens (2020), if food prices are raised due to climate change, it is likely an additional 77 million people will suffer from hunger by 2050.

Ziska (2017) goes in depth explaining how hunger has devastating impacts on human health, starting with stomach pain and cramping and ending in death. When the human body does not receive enough food it starts digesting fat cells and works to protect the vital organs. In addition to stomach pain, people often experience an increase in thirst, dizziness, weakness and issues using the bathroom. The body retains water, causes the limbs to look bloated, people can develop anemia and hormonal cycles are stopped. When the body has consumed all of the fat, it turns to muscles as a food source. The immune system is nearly nonexistent opening the body up to infections. Oftentimes people will die of that infection. If infection does not kill a person, eventually their heart and brain function will fail causing death. Inorder to avoid widespread famine, agriculture will need to adopt more sustainable production practices that will mitigate the impact of climate change.

Application in the Classroom

In order to adapt the current agricultural system in a way that will mitigate and withstand climate change, large changes will need to be made (Altieri, 2015). One of the strategies he believes people can utilize is to increase the genetic diversity of the crops grown. Altieri (2015) shares that modern agriculture relies heavily on monoculture crops which are vulnerable to pests and diseases. Increasing biodiversity would mean increasing the number of species that play specific roles in the ecosystem and building in natural redundancy. Doing this would ensure that if one species failed due to a fluctuation in the climate other species could fill that role and the ecosystem would not be interrupted. In practice, Altieri (2015) believes this could look like a farmer growing multiple varieties of the same crop in the same field versus growing them in separate monoculture fields. This strategy could also include planting different crops together that provide mutual benefits. This can be done by planting between rows or by planting in strips that allow for interaction and are harvestable by current technology. Crop rotation is an agricultural practice that is commonly used today, most frequently between soybeans and corn (Philander, 2012). Corn requires a large amount of nitrogen, and soybean roots utilize a bacteria to fix nitrogen into the soil.

Soil conservation is another important step to producing sustainable crops. One way to protect soil health is by reducing the amount of tilling on the field and utilizing cover crops. Reduced or no till reduces soil erosion and helps replace soil nutrients through decomposing organic matter (Philander, 2012). Cover crops can be utilized to reduce weeds and help fix nitrogen into the soil (Alterie, 2015). Combining these

methods with a rotational grazing system and windbreaks can help the field produce more food while increasing soil productivity.

In order to adapt to climate change, humans will need to be smart about water conservation. One way to do this is to capture water when it is plentiful and save it for when it is needed most (Alterie, 2015). This can be accomplished on both small and large scales, by utilizing rain barrels to collect water for the yard and garden to utilize artificial lakes to store water as ice in high climates (Ziska, 2017).

If precipitation is not as frequent, Ziska (2017) explains how condensers could be used to create water underground using condensation and solar energy. Using drip irrigation systems can deliver water to a plant one drop at a time, either just on the surface or underground near the roots. Orchards and vineyards that have utilized this watering system have drastically decreased their water consumption.

Some crops, such as corn and sugarcane are being utilized as a biofuel to help offset dependence on fossil fuels. The utilization of corn to make ethanol is not a perfect solution because it drives up demand and therefore the price of corn (Philander, 2012). Research is being done to try and make cellulose material a more efficient solution. If this is accomplished it would mean that the grain could be used for feed, whereas other plant materials such as the stem and leaves could be used as fuel.

Genetic engineering is another tool to use in climate adaptation and mitigation. A paper written by Ouyang (2017) explains how Genetic engineering allows scientists to edit, add or delete a specific section of genes. Scientists have used this technology to create crops that contain pesticides, have an increase of beta-carotene, and are immune to the herbicide glyphosate (Ziska, 2017). While complicated, scientists could use this

technology to create crops with an endless list of traits that would be better suited to surviving in a changing climate (Ouyang, 2017). This technology is not a magic bullet, it takes time and money to develop GMO crops (Ziska, 2017). It also opens ethical questions about where genetic modification should stop and whether companies should be allowed to patent genetic material.

The livestock industry has a few avenues to become more sustainable. Manure can be managed in a more sustainable way by utilizing anaerobic digesters and capturing the methane to use as renewable energy sources (Philander, 2012). The manure could be used as a fertilizer. The emissions produced through enteric fermentation can be reduced through selecting animals that are more efficient in digestion or changing feed stuff (Grossi, 2019).

One of the largest barriers to adapting to and mitigating climate change is the human condition (Zinska, 2017). Climate change is a huge, slow acting threat that looms ever closer. Individuals and governments around the world need to work together to make any real impact on avoiding the worst case scenario of climate change. Lobbying companies from the fossil fuel industry have invested in denying the effects of climate. While science does not back their claims, it is common for members of the public and congress to still deny that climate change is not an issue. For this reason, it is important that people understand the threat that climate change poses and can identify ways to help prevent the worst case scenarios.

One of the main goals of agricultural education and other career and technical education programs is to prepare students for the workforce. According to Lamm in 2019, the agricultural industry has been working towards more sustainable practices. In

order to be sustainable, the practices need to enhance and protect natural resources and ecological cycles, be profitable, reduce energy consumption, and ensure the safety and quality of the food and other products produced. In Addition to Lamms study, Williams (1998) found that the practices being implemented need to improve the socioeconomic status of both producers and their communities. In order to accomplish these goals the agricultural sector needs leaders that are innovative and knowledgeable about the complex issues that need to be addressed on a scale that stretches from local to global (Lamm, 2019). Teaching students about sustainable agriculture practices will give them the skills to not only join the industry, but also make informed decisions as consumers (Williams, 1998). It also allows agricultural educators to utilize applied science and technology concepts in their classrooms. However, teaching about climate change can be a contentious issue in a classroom due to the polarization that politics bring.

Conclusion

Climate change is an existential threat to modern society. As greenhouse gases increase in the atmosphere, temperatures around the globe will rise. Causing a disruption to the article ecosystem and hydrologic cycle. The melting of permafrost soils will release more methane into the atmosphere which could cause the global temperatures to rise beyond the acceptable two degrees of warming currently predicted. The change in global temperature will make the process of growing crops and raising livestock more challenging. The higher temperatures will make fresh water more scarce and could cause an increase in diseases, fungi, and pests. The increased carbon dioxide is likely to benefit highly adaptable plants like weeds more than the genetically similar crops we plant today.

In order to reduce the chance of global famine, agriculturalists, politicians, and everyday citizens need to enact changes. The largest impact we can have on reducing greenhouse gas emissions is by eliminating the use of fossil fuels. However these fossil fuels are tied tightly to the economy and to the production of our food supply. Finding and transitioning to alternative energy sources is an essential step to reducing the impact of climate change. Farmers can adopt more sustainable growing practices, like increasing the biodiversity of their fields sto reduce the chance that a severe weather event will wipe out an entire crop. They can also change feed rations for ruminate animals and change the way they manage manure to reduce the greenhouse gas emissions caused by the livestock industry. We can utilize agricultural technology like genetic engineering, drones, and sensors to better utilize the resources we have.

In order to enact widespread changes, citizens need to have a basic understanding of how climate change is happening, and be able to understand the pros and cons of how to mitigate its effects. Schools can help this process by educating students about climate change, its causes and its consequences in an engaging manner. The sustainable agricultural curriculum will help meet these needs.

Next Steps

Chapter Three will lay out the specific units that will be covered in the sustainable agricultural curriculum. The next section will identify the target frameworks and educational standards that the curriculum will cover. In addition, the specific pedagogical theories that will determine the instructional and assessment strategies will be identified and explained. Finally, the chapter will explain the ideal audience for the

sustainable agricultural curriculum and the steps for developing and implementing the curriculum.

CHAPTER THREE

Project Description

Overview

My capstone project will identify the best resources for a sustainable agricultural curriculum that can be implemented in a 9th-12th grade agricultural class. This chapter will describe the steps that will be taken to create the curriculum. I will also explain the pedagogical approaches that will be used in the curriculum along with the research that supports it. This chapter will identify the ideal setting and audience for the curriculum, and highlighting the materials and background knowledge that will be required to implement the curriculum. The chapter will then explain the timeline for developing the curriculum. Finally, the curriculum evaluation system will be explained to ensure it is a quality product.

Project Description

This chapter will identify the best resources for a sustainable agricultural curriculum that can be implemented in a 9th-12th grade agricultural class for my capstone project. This curriculum is intended to be used in a semester-long class with students in 9th through 12th grade. The curriculum will utilize a variety of pedagogical practices, but the main focus will be on inquiry and project based learning. According to the book Contemporary Science Teaching Approaches written by Funda Ornek and Issa M. Saleh (2014), inquiry-based learning is a way for students to engage with their learning instead of being passive sponges learners. It allows students to work together and use their resources to solve real world problems. Inquiry-based learning allows students to discover and prove concepts through projects and experimentation. According

to their book, concept mapping is a way to facilitate students making these connections and drawing conclusions. While creating my curriculum, I will be drawing on the research conducted by Ornk and Saleh.

Robert Capraro, Scott Slough, Mary Capraro, and Jim Morgan wrote a book on project based learning in STEM courses in 2013. This book will be one of my main sources for information on incorporating project-based learning in a sustainable agricultural curriculum. According to their book project-based learning empowers to work together while developing problem solving, communication, and critical thinking skills. These skills fit well in the science-based curriculum that will be implemented.

The content covered in each unit will be based upon the Minnesota Agricultural Framework Standards for Natural Resources and Environmental Service Systems along with relevant 9-12th grade common core standards. The curriculum will pay special attention to reinforcing the 9-12th grade science standards. I am emphasizing the importance of science standards because some agricultural classes are taught for science credit. Therefore it will be useful to ensure that the science standards are being incorporated into this curriculum.

Unit One of the curriculum will focus on introducing students to climate change, how scientists are able to correlate it with human activities, and how scientists predict climate change will affect different aspects of life on earth. Students will utilize the inquiry process to form their own opinions about the topics we cover in class. A variety of formative assessments will be utilized based upon personal reflections, and completion of lab based activities. For the summative assessment I want to avoid tests and quizzes.

Instead, the curriculum will focus on projects or papers to assess students' understanding of the topic. I expect this unit to take approximately three to five weeks.

The second unit will focus on agriculture's intersectionality with climate change. The class will analyze how agriculture contributes to climate change, and how climate change is impacting agriculture. For this unit I would like to bring in community experts to help students evaluate real life situations dealing with climate change and agriculture. An example of this could be evaluating how drought impacts crop production, and how poor crop production impacts the livestock industry. This unit will contain a number of labs that allow students to see these issues in person. This unit will be a bit larger due to the amount of content and may be broken down into smaller subunits of plant science and animal science. I expect this unit to take five to seven weeks.

The third unit will focus on addressing climate change. This unit will first assess how climate change is being addressed on a global scale. We will evaluate the sustainability goals utilized by the United Nations, and look into the work being done by global groups. The second section of this unit will focus on how the United States is addressing climate change. This will be a mix of looking at policy, and private corporations plans to move to greener technologies. Finally we will evaluate what is being done in Minnesota to address climate change. The final assessment of this class will be working in a small group to identify and propose a solution to a local environmental issue. Each group will present at the end of class, and if time allows I will invite community leaders to their presentations.

The sustainable agriculture curriculum that I plan to create will encompass four large units that will take approximately four to six weeks each. The main pedagogical

practices will be focused on inquiry and project based learning. I am utilizing that form of instruction due to the fact that studies show it increases engagement and student motivation. Each unit will build upon one another to ensure that at the end of the class students will be able to identify and propose solutions to environmental issues that contribute to climate change. The aim of this class is to not only inform students about climate change and its impact on the food system, but to empower students to enact change.

Setting and Audience

The curriculum I am creating is intended to be used with 9-12th grade students in an extracurricular agricultural class. While science standards will be covered, this curriculum will be focused on the interplay between agriculture and climate change. Therefore this curriculum should be taught by a licensed agricultural teacher.

The curriculum will be designed with a class of twenty-five students in mind. All labs, projects, and materials will be written out to accommodate that number of students. I chose that number due to the fact that twenty-five students is a common class size for the classes I personally teach.

The intended audience for this project is my own class, but it could be adapted to use in other settings. I teach in rural Minnesota, in a school that serves approximately 240 students 9-12th grade. Students at my school have had two trimesters of agriculture between 7th and 8th grade, therefore they come in with some agricultural background. The demographics of the school I teach at, are 94% white, with 6% minority. 14% of students qualify for free lunch, and 8% qualify for a reduced lunch. The ratio between male and female students is around 48% female and 52% male.

In order to create this curriculum I will need to keep my audience in mind. The curriculum will need to account for expected background knowledge and lived experiences. The curriculum will also need to be tailor to be culturally appropriate and sensitive to the demographics of the area.

Timeline

This section of the paper outlines the steps that will need to be taken to create my sustainable agricultural curriculum and complete the capstone project.

The first step will be to select appropriate standards for each unit to ensure that the key information will be passed on to students. Collaborating with my principal and science teachers will ensure that my curriculum will not be redundant. I will also be able to identify the key standards that I can help reinforce in the sustainable agricultural class. I expect this first step to take approximately one to two weeks.

Once the main standards have been Identified, then proceed to writing a detailed unit outline. Each outline will include specifics on how each standard will be covered and in what order they will be covered. Main vocabulary terms will be highlighted and any sources that can be used for teacher background information will be identified. The outline will also include a more detailed timeline for each unit. This step should take me between two to three weeks.

After completing the outline, detailed lesson plans will be created for each unit. The lesson plans will include instructional materials, essential questions, and a detailed description of how to utilize the materials. The lesson plan will also include suggestions on how to modify instructional materials for students with Individualized Educational Plans. I would also cross reference the lesson plan with common core standards to ensure

that all the standards being reinforced are identified. This step will take the longest and should be completed within four to six weeks.

The final steps would include reviewing the curriculum to ensure that all standards are being met and that all lessons can be accomplished in a school setting. Once this review is completed the curriculum would be ready to be reviewed with the principal to get the go ahead on implementing it in the classroom. Once the curriculum is approved it would be used with students and then revised based upon the successes and failures of each lesson.

The capstone project has been a labor of love, with over forty hours of researching, writing, and editing. The first chapter was completed in June of 2021, taking approximately three to four hours to write and edit. The second chapter took much longer than the first, with over thirty hours of researching, writing, and editing put in. The chapter was completed at the end of August 2021. The third chapter took around three to four hours to research, write, and edit. The finalized version of all three chapters was submitted on August 28th.

The next step of completing the capstone project is writing the curriculum. This will take place during the months of September and October, with editing being completed early november. Chapter four, the assessment of the capstone project, will be completed by the end of November. The final paper will be completed and submitted by the middle of December, with a publish date near the end of December.

Assessment

To assess the curriculum I would present it to my principal for review. They would ensure that the curriculum would be a good fit for the classroom and that it covers

the appropriate standards. Once the curriculum has been reviewed and approved, it would be implemented with students. During the implementation of the curriculum, student feedback would be an essential part of evaluating the curriculum. I would utilize a combination of student feedback forms and student assessments to identify the aspects of the curriculum that need to be improved. Once the curriculum has been revised I would look to share the curriculum with other agricultural teachers at a professional development workshop.

Conclusion

In order to create the sustainability agriculture curriculum, I will need to combine the research, audience knowledge, and my time management. The curriculum will be based on inquiry and project based learning, with an audience of 9th through 12th grade students in an agricultural program. Students will learn in depth information on climate change and how it affects the production of food, fuel, and fiber. The pedagogical foundation for the curriculum will be inquiry and project based learning to encourage students to be engaged with their learning. Students should leave the course having gained a lot of knowledge about climate change and agriculture, along with the skills to analyze and draw conclusions about their connections. Students will also be able to work with peers to discuss and solve complex problems.

What's coming next

Chapter Four will be a reflection on the process of writing the capstone project and the sustainable agriculture curriculum. The chapter will discuss what I have learned from the process of writing the sustainable agriculture curriculum and assess what research was most helpful during that process. It will also explain how the creation of the

sustainable agriculture curriculum will impact my teaching practices and how that curriculum could be distributed to other agricultural teachers.

CHAPTER FOUR

Introduction

This chapter is a reflection on the development of my capstone project which was creating a sustainable agricultural curriculum for students in a 9-12th grade classroom. Both the implications and limitations of the curriculum and research will be analyzed. Additionally, this chapter will identify the opportunities for further research and curriculum development that could be based upon my own project. Finally this chapter will share how I intend to utilize the curriculum in my own teaching practices, along with identifying ways to share the curriculum with other agricultural and environment educators.

Personal Reflection

The process of creating a sustainable agricultural curriculum was both gratifying and challenging. My original plan was to create a semester-long curriculum; however, I quickly realized that such a large curriculum would make it difficult for other teachers to implement the curriculum into their own classrooms. For this reason I decided to focus on making the curriculum a single unit. Scaling down the project gave me the opportunity to identify the key points I wanted to get across and create documentation that would be usable for other teachers.

I was also struggling with trying to make an entire semester's worth of notes, worksheets, labs, and other documentation in the few months of this project. The majority of my course work was completed during the covid 19 pandemic, which allowed me more time to focus on classwork during the school year. For my school the 2021-2022 school year has returned to precovid workload. Throughout the process of writing this

paper and developing the sustainable agriculture curriculum, I discovered that I produce my best work when I have large chunks of uninterrupted time. I have been in very short supply of uninterrupted time this semester and decided that taking a more focused approach to the curriculum would allow me to produce a better product.

Revisiting the literature review

Along with discovering my best work mode, I also learned a lot of information from writing this paper. The literature review allowed me to really examine the science behind climate change and how it is affecting agriculture. I especially found the book Our Daily Bread written by Lewis H. Ziska. The book was written in a conversational tone that made it easy to understand and it covered both the consequences of climate change for agriculture, along with how agriculture is currently contributing to climate change. Before completing this project I knew that climate change was an issue, but I did not understand the catastrophic effects it could have on our food supply. I also learned about how scientists measure the historic greenhouse gasses in the atmosphere via looking at air bubbles in glaciers.

Living in a rural community I often get push back about the existence, causes of, or effects of climate change from students and parents that follow a more conservative viewpoint. Before completing this project, I would struggle to dissuade students from dismissing climate change altogether. That is why the first activity in the sustainable agriculture curriculum is a worksheet that asks students to identify what they know about agriculture and climate change, and identify how they have learned that information. The first lesson of the unit is examining how scientists have proved that climate change is happening, and how they have identified specific sources of greenhouse gas pollution. I

included this information into the curriculum because I have found it is easy to take for granted that students know what climate change is and they think it is a problem.

Implications

One of my goals for creating this curriculum is that it would help rural agricultural students see climate change as an issue that will affect them. I have often seen students be skeptical and reluctant to discuss climate change. They often have arguments about the topic that seem to stem from political points versus scientific facts. I worry that the agricultural industry will focus on denying their impact on climate change instead of working to find sustainable solutions to the issues. I hope that teaching students about how it will affect our food supply will spark them into action on their own farms and in their communities. I believe that my curriculum opens the doors for research about how sustainable agriculture curriculum changes students' views on climate change, and whether the newly acquired knowledge results in a change of actions.

If the curriculum did cause students to change their thoughts and actions, it could cause local farmers to adapt farming practices to be more environmentally and climate change friendly. I would also be curious to see if students learning about these issues would increase the demand for climate change action and policies in rural areas.

Similarly I believe that research could be conducted on how inquiry based learning changes a students feelings on a controversial topic. I would like to see if the learning approach sparks a lasting intrinsic motivation versus a short term interest.

This curriculum will meet the goal of teaching agriculture students about the validity and reality of climate change and its impact on our food system, but more research would need to be done to determine if this knowledge is enough to change a

students thoughts and actions on climate change. I also hope that some students would take this information and pursue it into an agricultural career where they could help develop and implement new technologies to adapt and reduce climate change's impact.

Limitations

Despite the implications of a sustainable agriculture curriculum, there are a number of limitations to discuss. For one the curriculum is a single unit built for 9th-12th grade students. The impact of a single unit that takes approximately six to eight weeks will be limited compared to an eighteen week semester course or a concept that is woven throughout the educational system. In order to see a widespread impact on climate change and agriculture, it would need to be incorporated into multiple classes, and grade levels.

Along with a limitation of time, there is a limitation on the resources available to high school students. This means that the labs used to demonstrate the effects of climate change on crops are fairly limited and may be challenging to complete if the teacher does not have the grow lights. The teacher may also be limited in their desire or ability to address a real issue in the community that relates to climate change and agriculture. If they do not have the support of the community members it could cause controversy for the teacher or the school.

Additionally, there is not currently a way of identifying the impact that the curriculum is having. Research would need to be conducted in order to measure the real outcome of the curriculum.

Future Research and Projects

In order to address the limitations of the project, further research and curriculum development would need to take place. This curriculum will meet the goal of teaching

agriculture students about the validity and reality of climate change and its impact on our food system, but more research would need to be done to determine if this knowledge is enough to change a students thoughts and actions on climate change.

One area that research could be conducted is on how inquiry based learning changes a students feelings on a controversial topic. I would be interested in seeing if the learning approach sparks a lasting intrinsic motivation versus a short term interest. This could be done by setting up a study that follows students' feelings on climate change from the end of the unit to a few years out of high school. The study could see if the students chose to go into a career focused on sustainable agriculture or climate change mitigation.

Communicating Results

The curriculum created for this thesis project will be utilized in my 9th-12th grade agricultural classes. Specifically in my wildlife and natural resource class while discussing humans impact on the environment. I will also share this research and curriculum with other agricultural educators. The Minnesota Association of Agricultural Educators (MAAE) hosts two workshops every year; a weekend in January and a five day conference in July. I could present my curriculum in a workshop format at either one of those events or I could submit the unit to the innovative ideas contest. Additionally, similar conferences and contests take place at the National Association of Agricultural Educators (NAAE), allowing the curriculum to be explained and shared on a national level. There is also opportunity for this curriculum to be shared on the NAAE Facebook page, or in the MAAE google classroom folder where agricultural teachers from across the United States post and ask for curriculum ideas.

Benefit to the profession

In addition to benefiting the agricultural education profession, the curriculum will also promote environmental education. The term environmental education encompasses a wide range of educational experiences; from a traditional school setting to environmental research centers and everything in between. The curriculum I created is designed for a unit in a traditional classroom setting, but many of the activities could be adapted to fit other educational environments. For example the experiment showing how different temperatures affect crop growth could be scaled up in an environmental educational center to show how these crops look at a variety of life stages.

The curriculum is also adaptable enough to fit into a biology or earth science course. This could increase students' learning on how to sustainably grow food while reducing the impact our food system has on the environment. Making students more familiar with how the world systems work will hopefully steer students into making healthier choices for the environment.

Conclusion

The process of completing my thesis and sustainable agriculture curriculum has been filled with a variety of ups and downs. The final product looks different from what I first intended it to be. However, those changes have made the curriculum more adaptable and useful to a wider audience of teachers and students. Despite the limitations on time, and materials, further research and curriculum development could measure and increase the knowledge of sustainability, agriculture, and climate change.

For now, the sustainable agriculture curriculum can be shared amongst both agricultural education and environmental educators. The curriculum will hopefully

inspire both teachers and students to address local environmental issues and make more environmentally friendly decisions in life.

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