Expanding Climate Change Education in Agricultural Communities: Lessons from the U.S Midsouth

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Abstract

The U.S agricultural industry is a major player in the global market, and changes in climate that impact the industry have implications for both domestic and global food security. Existing studies have revealed a disconnect between agricultural stakeholders and the wider climatological community which impedes the process of informed decision making in response to climate-related changes in agriculture. Furthermore, the topic of climate change is not well-represented in national and state science education standards. We describe Climate Literacy for Agriculture and Sustainable Societies (CLASS), a collaborative project that aims to both bridge this gap in perception and understanding regarding climate change among stakeholders in rural communities and enhance the educational curriculum in high schools and higher education institutes. Beneficiaries for this project are students and educators at the secondary and post-secondary level and stakeholders served by the partnering universities. The final products consist of college level courses, dual-credit courses for secondary schools, and educational materials for agricultural stakeholders with a focus on climate change. The project's goal is to assist today's students as they become part of the future agricultural workforce and to develop the knowledge, skills,

and adaptive strategies required to meet the challenges associated with a changing climate.

Keywords: agriculture, climate change, education, outreach, rural

Agriculture in the 21st century is faced with the grand challenge of providing for the needs of a growing world population in the face of a changing climate. The U.S agricultural industry is a major player in the world food market providing for a significant share of the global food supply. Therefore, any significant change in climate that impacts agricultural production in the U.S can have implications for both the domestic and global food supply. Furthermore, climate change could influence corresponding impacts on food security (Molotocks et al., 2021). Currently in the U.S. there appears to be a disconnect between the knowledge and perceptions of the impacts of climate and climate change among people involved in and out of agriculture. It is apparent that a knowledge gap exists in basic understanding of the science of climates and climate change and how our everyday lives are impacted. Many citizens lack the willingness to expand their understanding of these issues because of a lack of perceived relatability or dislike for the information (Kahan et al., 2017; Kunda, 1990). Disinterest in turn impedes the process of making informed decisions and could potentially hinder the preparation of the workforce for mitigating risks related to climate change in agriculture. Considering the issues addressed above, climate change education emerges as a crucial area of concern for K-12 educators, students, college students, as well as agricultural communities.

Research has shown that people with a basic understanding of the sciences are more concerned with addressing climate change (Leiserowitz, 2010; Miller, 2012). For the U.S agricultural industry to be better prepared to deal with the uncertainty of climate change, it is key to improve climate literacy in society through education, communication, and outreach strategies. Furthermore, the topic of climate change is not currently well-represented in national and state science education standards (National Science Foundation, 2010). Climate change education has emerged as an important subject to be included in the curriculum in agricultural colleges and universities, and more importantly in smaller non-Land Grant institutes with a primary focus on 4-year undergraduate agriculture programs that place an emphasis on regional projections.

According to a study conducted by the Higher Education Climate Adaptation Committee (Dyer & Andrews, 2012), higher education institutions can add to the preparedness of the society to adapt to the impacts of climate disruption by promoting research and education that centers on the appropriate adaptation strategies. Furthermore, the study recommended that higher education institutions take a proactive approach to climate change adaptation by enhancing curricular offerings on climate adaptation in core courses and by the means of electives with specialized topics on climate change. Colleges of agriculture are well positioned for these types of course opportunities given the breadth and connections between agriculture and the natural sciences. Finally, the study suggested that higher education institutions can serve as potential focal points in their local communities for developing, testing, and disseminating knowledge about regional climate projections and relevant adaptation strategies. Thus, a project that considers the importance of the intersection between regional knowledge and support for regional, non-land grant institutions is vital for the next phase of climate change adaptation.

A study by Prokopy et al. (2015) showed that while more than half of the respondents to a survey of climatologists stated that climate change is occurring and humans are mostly responsible for it, less than a fifth of the agricultural educators in selected Midwestern states did, and slightly more than a tenth and slightly less than a tenth of the agricultural advisors and farmers, respectively, believed that climate change is anthropogenic. There is clearly a disconnect between agricultural stakeholders and the wider climatological community comprising climate researchers, educators, and scientists and this project is designed to narrow the difference in perception and understanding. The gap between the two entities creates misinformation and confusion on the nature of climate change as it relates to agricultural productivity among stakeholders in the agricultural community (Cook, 2022). This confusion is aggravated due to the potential impacts of climate change varying significantly for different agricultural products, and in different regions.

The studies mentioned indicate that there is a need for more climate-based education focusing on the basics of meteorology and climatology and its potential impact on agriculture at the secondary and college level. It is important for students to be exposed to these topics in an objective, scientific manner as it will enhance their ability to fully appreciate how much it applies to the field of agriculture beyond the obvious temperature and moisture requirements for specific crops and livestock. In addition to basic inferences, students may possibly gain a rudimentary understanding of how world markets for their products are impacted by weather and climate events in other parts of the world through the access to digital media.

Another important consideration is to educate students on how possible future changes in climate will influence agriculture. Traditionally, most university agriculture curriculums focus on teaching students about current agronomic practices and depending on faculty expertise, may have limited focus on the science of changing climate conditions. Students will need to evaluate how changing climate can influence the standard methodologies that they have learned. Students who have an understanding in how agriculture might be practiced around the world may be able to critically think about the issues related anthropogenic climate change based on their increased global competence (Inegbedion & Islam, 2020).

Importance of The Project in the Study Region

The agricultural industries in both Tennessee and Kentucky are major contributors to the respective states' overall economies. Tennessee is among the top ten states nationally in the production of row crops such as corn and

soybeans, beef cattle, tobacco, fresh tomatoes, hay and cotton (USDA, 2019). The state also ranks among the top five states in the number of meat goats and equine. Agricultural production generated more than 4 billion dollars in farm cash receipts according to the census data for the year 2021. In 2022, Tennessee had nearly 69,500 farms comprising of more than 10.7 million acres statewide; the average farm size being 154 acres. Northwest Tennessee is a major row crop production zone in the state, with some of the top soybean producing counties in the state being in this region. Given the importance of agricultural production in the state, and particularly in its northwest region, climate change may have implications for the local communities that critically depend on agriculture for their sustenance. According to a study by Karetinkov et al. (2008) for Tennessee, unmitigated climate change impacts could lead to an increase in temperatures between 2º and 6º C (3.6º and 10.8º F), and an average increase of 7 percent for precipitation relative to the current climate. They suggest that agricultural production in Tennessee could initially increase for crops such as soybeans due to an increase in temperature, precipitation, and carbon dioxide levels. However, extreme events such as heat waves, droughts, and floods, will also increase, and nullify the initial economic gains derived from altered growing conditions in the high production areas in the state.

Agriculture is also a major economic sector in Kentucky and the state is home to approximately 73,500 farms. According to the 2021 census of agriculture, total value of agricultural products sold in Kentucky was $ 6.9 billion with equal contributions from both crop and livestock sector. Kentucky ranks 4thin the country in terms of market value of agricultural commodities. Average farm size in Kentucky is 176 acres, compared to the national average of 445 acres. Leading crops in the state include soybeans, corn and wheat and approximately 4.3 million acres are allocated annually to these crops. Huge variations in temperature and rainfall due to climate change in an agriculturally dependent economy would result in catastrophic consequences especially in terms of loss in food production and indirect effects on rural economy.

Given the significance of the agricultural industries in the respective areas served by the partnering institutions, the Climate Literacy for Agriculture and Sustainable Societies (CLASS) Project aims at addressing specific need areas in the categories of education, research, and outreach. Addressing these need areas will be of immense value at the state (Tennessee and Kentucky), and the regional levels (northwest Tennessee and western Kentucky). The goal of CLASS (see figure 1.) is to assist today's students, as they become part of the future agricultural workforce in developing the knowledge, skills, and adaptive strategies required to meet the challenges associated with a changing climate. Additionally, our current study also infuses the scholarship of teaching and learning (SoTL) into the programmatic planning and delivery of CLASS as each part of the initiative was evaluated fo effective design and delivery of high impact educational offerings.

This project seeks to approach SoTL and knowledge delivery of climate change education by enhancing capacity for introducing climate change education in the curriculum for undergraduate and graduate agriculture classes in the two partnering universities respectively, and for dual-enrollment classes at local high schools located in strategically important regions for agriculture in the states of Tennessee and Kentucky. This project also aims to build strategic partnerships for student involvement in climate change related research, for workshops and trainings for faculty across both campuses, for agriculture educators in high schools, and for interested producer groups in climate change impact evaluation in agriculture. Outreach will particularly be extended to FFA programs and 4-H clubs in the area high schools of the two partnering universities. Outreach activities will enable broad dissemination of the findings to a wide variety of stakeholders ranging from K-12 to industry partners.

Target Objectives of CLASS

The Education Objectives focus on incorporating climate change education in the curriculum for undergraduate and graduate agriculture classes in two partnering universities, as well as in high schools respectively located in strategically important regions for agriculture in the states of Tennessee and Kentucky. Additionally, the CLASS project will build capacity in the partnering institutions for developing both face-to-face and online teaching interfaces to deliver specific course offerings related to climate change and include professional development of faculty at both campuses focused on design, development, and delivery of online courses.

The Research Objectives consist of encouraging undergraduate and graduate level student involvement in a variety of research topics related to understanding of the science of climate, climate change, and its impact on agriculture. The CLASS-affiliated faculty emphasized a research element through SoTL to evaluate the effectiveness of face-to-face and online teaching of climate change education through coursework and professional development to influence future delivery of requisite content.

The Outreach Objectives intend to broaden the dissemination of the developed educational materials with a focus on climate change and agriculture to a much wider audience beyond the service area for each collaborating institution. This will be accomplished by participating in agriculture focused FFA and 4-H events, as well as conducting a workshop for K-12 educators in the region.

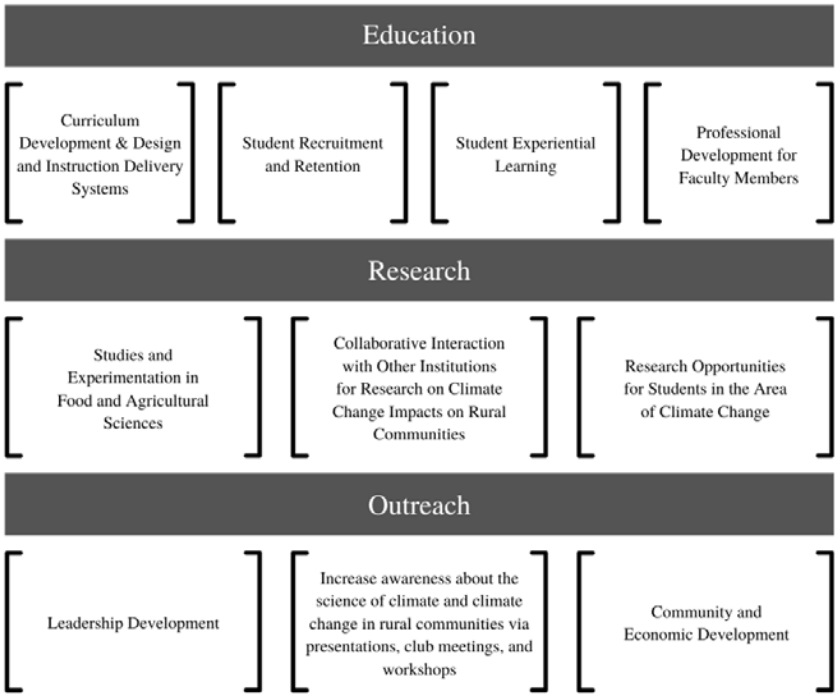
Methods

Theoretical Framework

The model guiding the initial development of CLASS was inspired by previous work in multiple spaces including experiential learning and the significant behavior change that stems from increased awareness to climate change (Halady & Rao, 2010). The theoretical model (see Figure 2.) was influenced by the model from Molthan-Hill et al. (2019) that was adapted from the Integration of Sustainability Matrix (Godemann et al., 2011; Rusinko, 2010). Initial objectives sought a transformation of education through a process where contemporary research was integrated into curriculum for students at secondary and post-secondary levels.

Figure 1.

Climate Literacy for Agricultural and Sustainable Societies (CLASS) Project Model



Note. The project model was a result of discussions with stakeholders and advisory team members who brought together previous experience with university curriculum, extension projects, and community outreach.

The framework above addresses specific intervention types that describe the breadth and relative age of each strategy. Piggybacking, or the integration of approaches that build off of existing curricular initiatives, came to be the focus of many efforts as the structures like dual-credit and youth programming already existed and moreover, curriculum in those programs that address applied STEM concepts. Summer coursework from the project becomes a showcase of mainstreaming as the curriculum for summer programming is in place but can be a shell for new courses with a selective focus on climate change action. Specializing directs new curricular structures with a narrow focus and connecting very similarly designs new structures but more broadly with intention of cross-disciplinary collaboration. The model allowed the collaborators to design education and research opportunities in climate change and adaption strategies to mitigate future impacts on the agricultural industry. The agricultural workforce of tomorrow will require these critical skills to be successful in managing the risk posed by climate change to the agricultural sector. Additionally, the framework closely aligns with the partnering institutions' engagement to assist in the economic development of regional and local communities that rely on agribusinesses for their sustenance in the way of specialization and connection.

Procedures

Educational procedures consisted of developing a series of sequential online / in-class courses for both undergraduate and graduate level study focused on climate, and impacts of climate change on agriculture, as well as for dual enrollment credit in high schools. Collaborating institutions worked to develop specific course offerings through mutual discussions, a review of existing and current scientific literature, textbooks, and exchange of information from experts.

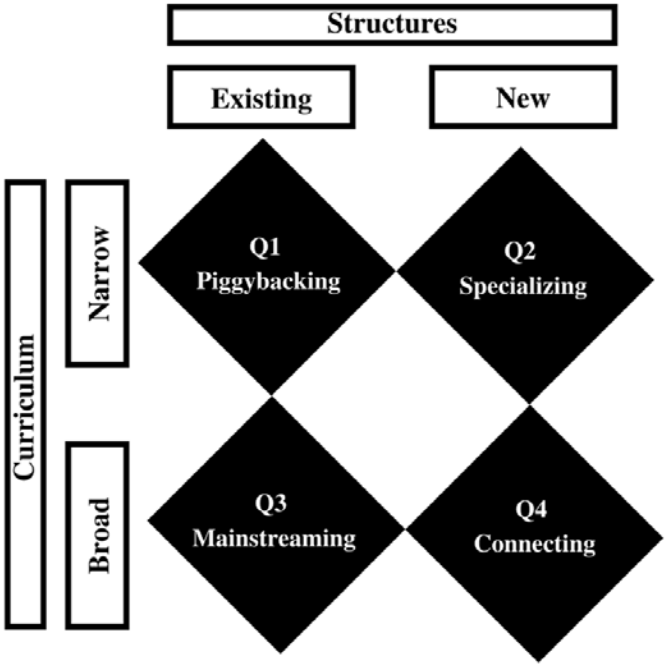
Research procedures focused on recruiting graduate and undergraduate student researchers for projects with a focus on climate change and its impact on agriculture and the environment. This was also extended to student research in the partnering institutions by conducting a willingness to pay survey study among students with a focus on financial implications for dealing with climate change.

Outreach Procedures consisted of interactive activities in agriculture focused FFA and 4-H events to disseminate knowledge on climate change to communities of interest. A climate wedges game was developed to enhance the interactive experience among participants while improving the understanding of the linkages between agriculture and climate change, cost-benefits of climate change mitigation policies, and efforts aimed to reduce the carbon footprint of the agricultural sector. Another major effort was focused on developing and delivering a virtual workshop for secondary educators in the final year of the project in northwest Tennessee/ Kentucky. The workshop design centered around content related to the science of climate and climate change impacts on agriculture and utilized educational and interactive material developed by the partnering institutes.

The project's activities were approved by the University of Tennessee at Martin's Institutional Review Board (IRB Approval# 2019-724-E05-4005).

Figure 2.

Theoretical Model for Climate Change Education



Note. Model from Molthan-Hill et al. (2019) which was adapted from the Integration of Sustainability Matrix (Godemann et al., 2011; Rusinko, 2010). Research and outreach are based on University Extension models for increased dissemination of findings from cross-institutional collaboration (Jeffrey, 2003).

Results and Discussion

Education Results

The partnering institutes continue to offer courses in the following areas developed at the graduate level as a result of this project: basic and advanced understanding of the science of climate and basic and advanced understanding of climate change. The following topics were fully developed and continue to be incorporated in undergraduate college-level courses at partnering institutions: domestic and global policy issues in climate change and agriculture, market related impacts of climate change on agriculture and risk management and evaluating and measuring economic impacts of climate change on agriculture.

Climate change education in the high school curriculum in the respective areas of the collaborating institutes continues to be introduced by means of dual-credit courses, and web-based materials with a focus on climate and impacts of climate change on agriculture. Throughout the project duration, a total of 605 high school students in the region were enrolled for an existing dual-credit course focused on contemporary issues in agriculture where the developed materials were integrated. Additionally, a new undergraduate-level dual-credit course on Agriculture and Climate Change was developed and incorporated in the academic catalog at the partnering institute in Tennessee and continues to be offered each semester since Summer 2021. A major focus of the courses offered under the climate change curriculum is to provide a basic understanding of impacts due to climatic variability on agriculture, the environment, and global food security, and exposing the students to an understanding of the impact(s) of climatic variability on the environment, agriculture, and related sectors. They also learn about tools and strategies that may be available to the population engaged in agriculture and related sectors to successfully and sustainably adapt to variations in weather and climate.

Research results

A total of 8 undergraduate students and 2 graduate students worked with faculty in the partnering institutes to assist with research activities related to the understanding of the science of climate, and its impact on agriculture. Students worked on a variety of survey-based research topics such as climate change education and awareness, public perception on environmental issues exacerbated by a changing climate, and mitigation strategies to combat climate change in the future. For instance, an undergraduate research project examined willingness to pay among students with a focus on financial implications for dealing with climate change. This study analyzed differences in college students' perception of willingness to pay for climate change mitigation efforts as affected by demographics, concern about the impact of climate change on agriculture, and existing knowledge about climate change. Among other variables, the need for more information about climate change had a significantly positive impact on the willingness to make a financial contribution for climate change mitigation efforts (Sartain et.al. 2020).

Outreach Results

Disseminating results to communities of interest: Over 200 high school students participated in the climate wedges game hosted by the collaborators and student workers of the project during multiple FFA events and 4-H events. Faculty and students involved in the project participated and presented their research findings at various regional, national, and international conferences and events with an emphasis on climate change science and education, such as the annual meetings of the American Meteorological Society, the Canadian Agricultural Economics Society, the Tennessee Academy of Science, and most recently at Oxford University, UK.

The CLASS (Climate Literacy for Agriculture and Sustainable Societies) educators' conference: The CLASS conference was initiated in the final year of the project to reach K-12 students and educators as ultimate beneficiaries of this multi-year project on climate change education. A specific focus was to host the first-ever K-12 educators' conference in the region with an emphasis on climate change science and education. A virtual 3-day conference with an emphasis on climate literacy and climate change education curriculum enhancement for high school agricultural educators was

organized June 15-17, 2021. The conference included 11.5 hours of programming and had 54 attendees in total from the states of Tennessee, Texas, Kentucky, Pennsylvania, and Alabama. Secondary educators participated (N=22), and 88.9% of the participating educators were identified as Agricultural Science teachers, with an average of 10.89 years of experience in the classroom. The virtual conference platform (Whova) statistics identified 32 Community Discussion Topics and 164 messages sent between participants. It was noted that 81% of the participants actively used the Web App for the conference platform, with a total of 309 session views, thus indicating participation both synchronously and asynchronously. Conference participants also received educator kits including books, measurement devices, and lesson resources.

An impact survey was administered six-month post-conference where all respondents indicated the use of climate chance education in their classroom. Three educators noted they were regularly collaborating with fellow conference attendees on projects because of meeting at the conference and every educator indicated a desire to attend a future event under the same theme for continuing professional development.

Discussion and Conclusions

As higher education institutions endeavor to better equip the upcoming generation with the tools and information to potentially mitigate climate-related changes in agriculture and related sectors, an integrated project model like CLASS could be instrumental in shaping the structure of current and future efforts in this direction. Furthermore, there continues to be an indispensable need for collaborative initiatives that aim to bridge the gap in perception and understanding regarding climate change among stakeholders in rural communities, and to enhance the educational curriculum in high schools and higher education institutes with a focus on climate change through piggybacking and specializing strategies. Studies have cited there are still hesitations to integrate wide-spread curricular offerings under the climate change education umbrella due to the lack of training and immense number of variables involved (Fahey, 2014; Busch et al., 2019). The results of the CLASS initiative however provide evidence that piggybacking and minor specialization work can pave the way for broader work and incite interest in students at the graduate level to research and teach in the space. Furthermore, a focus on the personally relevant issues has shown to lead to effective intervention (Monroe et al., 2019). CLASS focuses on teachers in the central southeast region of the US and addresses the impacts of climate change on agriculture that participants have grown around and thereby fostering a level of familiarity.

As was the case with most events and initiatives that required public interaction during the years 2020-21, the CLASS project was also faced with restrictions on travel, public gatherings, in-person classes, and events. The proposed in-person stakeholders' workshop could not be organized, as were the in-person collaborative meetings and conference presentations. The collaborators worked around this situation by using the virtual interface for teaching classes that were related to the grant and participated in virtual meetings as was feasible. Based on post-program surveys, technology was identified as a potential limiting factor for student engagement due to Zoom fatigue and a lack of connection with other participating educators and students through the interface of a screen rather than hands-on in-person instruction. In addition to technology, some educators also identified a difficulty in integrating animal care into climate change discussion. Educators identified an ease of integration of climate change in some subject areas because of the resources available to add to their pedagogical content knowledge but cited animal care as a subject seemingly removed from direct impact of climate change, despite there being direct impacts (Ponnusamy & Pachaiyappan, 2018). Moving forward, more work will need to be done in professional development settings to increase pedagogical content knowledge so that connections between topics and content that are related less obviously are highlighted with an emphasis.

Future efforts in this space will address both challenges to better serve the needs of educators in the region. The collaborators will continue to organize, develop, and provide information and educational teaching resources to be used in dual-credit high school courses, workshops, and events as mainstreaming and connection approaches. As was the focus during early efforts, engaging students in research on climate change science and education at the post-secondary level must be accompanied by studies exploring impact and successful dissemination or work to local stakeholders like farmers and those in the agricultural sector.

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