Assessing Teacher Practices Related to Precision Agriculture in Secondary Agriculture Education

by

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Abstract

Agricultural education was designed to reflect the agriculture industry, and since the recent increase in technology use in the industry, little research has been done to investigate what agricultural technologies are used in secondary agriculture classrooms. This study identifies the curriculum involving precision agriculture that is currently being taught and gains insight into teachers' decisions to integrate precision agriculture in their classrooms. Secondary agriculture instructors in Alabama and Illinois participated in this study and provided descriptive data about their personal characteristics and their decision to incorporate precision agriculture, as well as barriers that prevent them from incorporating precision agriculture concepts. Teachers indicated the importance and relevance of precision agriculture, but only half of the participants incorporate related concepts into their curricula. A Chi Square test revealed no significant relationships between the personal characteristics of teachers and their decision to incorporate precision agriculture concepts. The most important topics in precision agriculture were identified by participants as GPS, Soil Sampling/Land Management and Genetic Modification. Teachers indicated a need for professional development or teacher education focused on precision agriculture in multiple fashions, which reflects the need for similar education in the agriculture industry.

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List of Abbreviations

FFA	Future Farmers of America
CDE	Career Development Event
UAV	Unmanned Aerial Vehicle
UAS	Unmanned Aerial System
GPS	Global Positioning System
STEM	Science, Technology, Math and Engineering
ICT	Information and Communication Technology
IRB	Institutional Review Board

Chapter I
Introduction

Precision agriculture technology is a vital component of today's agricultural industry. The training and education for consumers of the technology (identified as agricultural producers) as well as specialists who are able to install, troubleshoot, maintain, educate, and develop emerging technology are increasing in demand. By incorporating precision agriculture technology concepts into secondary agriculture education curriculum, students will be better prepared to pursue careers in the agriculture industry.

Historically, precision agriculture has been characterized as using standardized methods such as crop rotation and fertilizer application to increase yields. Advances in technology and information technology have created the opportunity to farm in a more customizable way that allows agricultural producers to make informed management decisions (Lowenberg-DeBoer, 2015). Industry and producer demands of increased profits - combined with an increased transparency in agricultural practices and environmental conscientiousness - created a substantial push to farm with fewer inputs, higher efficiency and ideally higher yields. Global positioning systems, soil mapping, variable rate planting, unmanned aerial vehicle imaging and yield mapping are only a few of the technologies that have emerged. These tools share the goal of shaping the agricultural industry into a sustainable, successful, and efficient food source for the growing population.

New opportunities and challenges exist as precision technology practices become common practice in the agricultural industry. Research has described many challenges of technology adoption among agricultural producers, noting the increasing age of farmers and a lack of sufficient and effective education opportunities for farmers on the topic of precision agriculture technologies (Kitchen, et al., 2002). Precision agriculture education is necessary in a variety of ways, but is in somewhat uncharted territory. As new technology emerges, educational methods and structures must emerge to ensure the technology may be implemented to the fullest extent.

Adult education opportunities are needed to educate current producers. Educational events such as field days connect farmers to technology through demonstration and application. Adult education is necessary for adoption of technology in the agriculture industry. For younger generations who are the future of our industry, learning about the precision agriculture technology used in the industry in their secondary agriculture education courses will better prepare them for the world they are to inherit. The inclusion of agricultural technology in agricultural curricula will benefit student endeavors in agricultural and STEM based careers. Introducing precision agriculture technologies to the secondary agriculture classroom is a natural shift that accomplishes the main goal of vocational education: preparing students in classrooms that fulfill the technological education industries require of 21st century employees.

Technology utilization and purposeful application in classrooms is a trending topic in education. The benefits of incorporating technology have been studied extensively (Gorder, 2008). Student use of ICT is ubiquitous everywhere. Today, students are using personal devices and are comfortable with technology. Grouping educational trends such as classroom technologies and STEM education with precision agriculture technologies in secondary agriculture classrooms is a natural fit. The synthesis of these educational concepts benefit students through classroom achievement and career success. Identifying effective models and practices for integrating science, technology, engineering, and mathematics into Agriscience Education curriculum has been identified as a research priority by the American Association for Agricultural Education (Roberts, et al., 2016). Prior research indicated positive relationships between the use of STEM and agricultural classrooms. Smith, Rayfield and McKim (2015) outlined the relationships between STEM and agriculture, noting that "agriculture teachers are confident in their ability to integrate science concepts…students who engage in math integrated agricultural power and technology class scored higher on a postsecondary math placement test" (p. 182-201). Many agriculture teachers incorporate STEM into their curricula without realizing it because the educational structures of agricultural education and STEM align so well. As agricultural technologies emerge across the industry, finding ways to incorporate precision agriculture topics that include STEM principles will not pose a challenge to teachers (Stubbs & Myers, 2016). Many precision agriculture concepts already encompass science, technology, engineering and mathematics. The combination of technology uses to solve specific problems are endless; engineering and mathematical components of precision agriculture technologies are necessary for the technology itself to function, and can easily be investigated by students in a variety of settings and course topics. The flexibility of precision agriculture technologies across topics and educational structures is an enormous asset to teachers who choose to incorporate them into their coursework.

Statement of Problem

In order to create an agricultural educational learning environment that matches the industry, the use of technology in coursework must be relevant. Students enrolled in agricultural education classes are interested in learning skills that are applicable and relevant to the world around them. As the world changes, the classroom must also change. Updating curriculum, teaching in ways that are relevant and engaging, incorporating technology, and making connections across topics are only a few ways vocational classrooms can reflect the world today. As the age of secondary agriculture instructors (and farmers) increases, they may be less flexible in how they teach their classes. The danger of being inflexible in agriculture classrooms or teaching “outdated” concepts is that the students ultimately lose (Boone, et al., 2006). Students who learn outdated materials are not prepared to be active members of the present industry. A shift can be observed in the curriculum of agricultural content as educators are pushed to focus more on biotechnology and science-based topics and less on the grassroots content areas of mechanics and field agronomy (Boone, et al., 2006). Precision agriculture concepts blend biotechnology and agronomy or mechanical content together, marrying technology with real world application. By understanding the science and application of the technology, students can grasp the capabilities of the technology itself as it relates to course content and real world situations. The knowledge of what kinds of agricultural technologies used in classrooms across the U.S. is limited. In order to keep agriculture and vocational education curriculum relevant, an assessment of current teaching practices must occur.

Purpose of the Study

The purpose of this study is to identify the curriculum involving precision agriculture technology that is currently taught, and gain insight into secondary agriculture education teachers’ decisions of why they choose to integrate precision agriculture topics in agricultural curriculum. By understanding what is currently being taught by secondary agriculture education teachers, researchers may then be able to better provide opportunities for growth through professional development opportunities, industry network connections and educational workshops to encourage the incorporation of precision agriculture technology into curriculum.

This incorporation must occur in order to keep secondary agriculture education relevant and in tune with industry trends that ultimately affect the careers of agriculture education students.

Objectives of the Study

The research questions to be addressed in this study are:

1. Describe the courses and curriculum currently being used to teach precision agriculture concepts;
2. Describe participants by their personal characteristics and their incorporation of precision agriculture concepts in their classrooms;
3. Describe the relationships between participant personal characteristics and their incorporation of precision agriculture concepts in their classrooms;
4. Describe participants by importance and competence with respect to teaching precision agriculture;
5. Describe the barriers teachers identify that prevent them from teaching precision agriculture;
6. Describe the most important topics in precision agriculture and the relevance of precision agriculture in the areas of education and agriculture; and
7. Define the term precision agriculture.

Conceptual Framework

Theoretical components that were common in existing research included models based on adoption diffusion or diffusion of innovation in regards to the emerging technologies themselves. Inquiry or Problem Based Instruction models were common in education-focused works, highlighting the structure of agricultural education that encourages students to engage in the learning process. These theoretical common threads will be further investigated in the review of literature. Another consistent theme throughout the existing research was the concept of idea sharing among secondary agriculture instructors whether through professional development opportunities or social media venues that encourage innovation among teachers.

Rogers' (2003) Diffusion of Innovation theory is comprised of four main components: innovation, communication channels, time and a social system. The innovation element of the Diffusion of Innovation theory is composed of ideas that are becoming relevant, whether or not they are considered to be new or emerging. Technology concepts are often innovative ideas and follow the Diffusion of Innovation theory as people develop new ways to utilize technology. Communication channels are characterized as the process of sharing information or the spreading of innovations and ideas. Rogers (2003) discusses how homophily and heterophily affect the spread of ideas, stating that ideas flow more freely among homophilous individuals, or individuals who are similar in a variety of ways and work together towards similar goals. Heterophilous individuals tend to be quite different from each other and therefore have a more difficult time communicating and agreeing on the importance of ideas and innovations. Time is considered by Rogers (2003) to be the measurement tool of the entire process of learning about innovations to adopting them. The innovation-decision process consists of an individual's course of learning over time that begins with learning of an innovation, learning about the innovation, forming an opinion on the innovation and results in either adoption or rejection of the innovation (Rogers, 2003). Social systems are the final component of Rogers' diffusion of innovation theory. Social systems can be characterized as networks of individuals or units working together to accomplish a common goal, often groups of people or organizations. The leadership of some individuals or the normality of the group affect the flow of information and how it reaches individuals (Rogers, 2003). This element shares many characteristics with the idea of human capital, which describes how individual's professional and personal networks affect their decision-making process (Hunecke, Engler, Jara-Rojas, & Poortvliet, 2017).

Rogers' Diffusion of Innovation theory develops the process of innovation adoption and describes how groups of individuals within a social system can be identified based on the time it takes them to adopt innovations, and the attributes that commonly affect their decision-making process. These categories are innovators, early adopters, early majority, late majority and laggards (Rogers, 2003). The first group to adopt are called innovators, described as individuals who are comfortable with uncertainty and are capable of higher-level thinking in regards to concept application. Early adopters are characterized as being slightly more contemplative than innovators, are led by their opinions on the innovation and evaluate the innovation subjectively. The individuals that comprise the early majority group are often willing to adopt innovations, but rarely lead the way. They often take longer than both innovators and early adopters to contemplate adoption of innovations, often looking to their predecessor adopters for signs of success. Late majority adopters are cautious by nature and rely heavily on social norms to sway their decisions, they require little to no uncertainty surrounding the innovation in question. Laggards are the last group of units or individuals to adopt innovation. Laggards resist innovation adoption and often doubt the success of an innovation, exercising acute caution in the decision-making process (2003).

The attributes and attitudes of innovation adopters described in Rogers' (2003) Diffusion of Innovation theory are similar to the characteristics that influence decisions, intentions and behaviors described in Fishbein and Ajzen's (1975) theory of planned behavior. Fishbein and Ajzen (1975) stated that an "individual's intention to perform a behavior (behavior x) is influenced by their attitudes towards that behavior as well as their beliefs about the consequences of that behavior" (p.16). Intention to perform a behavior (behavior x) is also influenced by subjective norms and normative beliefs about that behavior (Fishbein & Ajzen 1975). The confluence of these theories consider behavior x to be the adoption of an innovation or idea. For this example, the innovation or idea is the incorporation of precision agriculture technology concepts which utilize STEM structures into secondary agriculture education coursework. Adopting this idea implies the consequence of the instructor updating curricula and learning new concepts, which is undesirable to late adopters and laggards, therefore they are resistant to the innovation and less likely to perform behavior x, which is in this example the adoption or incorporation of precision agriculture technology concepts into coursework. The individuals are influenced by their attitudes and beliefs towards adopting new innovations (Fishbein and Ajzen 1975). A similar example could be found with the opposite result, utilizing an innovator or early adopter as the instructor or individual. This individual's attitudes and beliefs towards adopting new ideas are positive, therefore they are more likely to incorporate precision agriculture technology into their coursework.

Scope of the Study

The scope of this study included (N =693) secondary agriscience education teachers in Alabama (n =169) and Illinois (n =196) representative of secondary agriculture education programs.

Population

Subject population consisted of certified secondary agriculture educators who are members of the National Association for Agricultural Educators. The membership rosters from Alabama (N=302) and Illinois (N=391) will serve as the populations for this study. Cochran's

Theorem (1977) was utilized for the selection of possible participants to ensure an equal sample distribution and account for sampling bias in the participant sample. Oversampling techniques will ensure a statistically significant instrument return rate for the replacement of non-respondents.

Assumptions

The following assumptions are made regarding this study:

1. The instrument to be utilized will elicit accurate and fair responses representative of the selected population.
2. The participants will fully comprehend the statements being presented within the instrument to assess their perceptions.
3. The participants will provide honest expressions of their knowledge base and experience.

Limitations

1. Practices related to the instruction of precision agriculture may exhibit a large variance in the type and model used for instructional delivery.
2. A perceived lack of understanding related to precision agriculture at the secondary agriculture education level.
3. Participants may fail to appreciate the emergence of precision agriculture education as a vital component of their instructional content areas.
4. Misconceptions and misunderstanding of precision agriculture.
5. Use of historical content delivery and the unwillingness to expand the existing curriculum.
6. Individual experiences and knowledge of the respondent sample related to their level of educational attainment.

Definition of Terms

Agriculture - The science or practice of farming, including growing crops and raising animals for the production of food, fiber, fuel and other products (USDA National Agricultural Library Glossary).

Agriculture Education - Agricultural education teaches students about agriculture, food and natural resources ("What is Agricultural Education?", 2018).

Barrier of Adoption - Anything preventing the adoption or integration of innovation (Batte & Arnholt, 2003).

Concepts – An abstract or generic idea generalized from particular instances (Concept).

Content – The matter dealt with in a field of study (Content).

GPS - Global Positioning System that tracks location and navigation through orbital satellite signals and receptors (GPS).

Inquiry-Based Instruction - Learning method based on active engagement or hands-on learning founded in theoretical learning cycles that encourage active critical thinking and problem solving from students rather than passive reception of information given by an instructor (Thoron, 2010).

Precision Agriculture - Precision Agriculture is conceptualized by a system approach to reorganize the total system of agriculture towards a low-input, high-efficiency, sustainable agriculture (Shibusawa, 1998).

Technology - The result of using technical processes to accomplish a task (Technology).

Chapter II

Review of Literature

Background

Existing research revealed support for educational efforts related to precision agriculture, noting a "natural learning process" regarding precision agriculture (Kitchen, et. al., 2002). Educational research efforts for adult agricultural producers are becoming more abundant as researchers attempt to increase adoption rates in precision agriculture technology emergence. There is a lack of research that focuses on the younger, future generation of agriculturalists with a natural knack for technology. Research also exists on the topic of Science, Technology, Engineering and Mathematics (STEM) in agriculture education, noting the specific ways that agriculture education teaches science, technology, engineering and mathematics concepts even before STEM was a buzzword in education (Stubbs & Myers, 2016). While these works exist on each topic separately, a study has yet to be published culminating these topics into applicable research to move agriculture education forward to match the evolution of the agriculture industry.

Classroom Technology

Technology's place in the educational setting has evolved in recent years. Sutherland, et. al., (2004) discussed the role of Information and Communication Technology (ICT) in the classroom and an emphasis is placed on the contrast between the usually abundant availability of technology with the low utilization of that technology in classrooms. Sutherland, et. al., (2004) noted the common assumptions of teachers being that in order to incorporate ICT into their classrooms, they will have to change their teaching styles and pedagogies to make room for this “new” trend. Support for ICT use in classrooms can be founded on the influence of technology use outside the classroom has on students. While students use technology constantly outside the classroom, the absence of similar technology inside the classroom creates a link between teachers and students that is simply not being made. By understanding the students in the classroom and their learning tendencies, teachers will better be able to identify how ICT might be most beneficial to learning (Sutherland, et al., 2004). The familiarity with technology today’s students exhibit is often attributed to their generation, called “Millennials”.

Millennials have been born into a time and generation in which technology already exists and is used everywhere. The use of mobile technology outside the classroom by millennials span many areas of their lives including communication and entertainment (McMahon & Pospisil, 2005). Communicating via text messaging, online chatting, and even video calling is frequent among millennial users who also find entertainment through video games, music and TV which can all be accessed from their mobile devices (McMahon, et. al., 2005). McMahon, et.al., (2005) found that millennials viewed technology as a necessity and expressed the desire for integrated technology across multiple areas in life. This constant use of technology has instilled in millennials a built-in skill of multitasking (McMahon, et.al., 2005) as they use multiple applications and types of technology simultaneously on a regular basis. Howe and Strauss (2000) found that millennials’ multitasking skills extend past their use of technology and enables them to be more experimental in their lives and career searches, breaking from the previous generation’s traditional trend of staying in one job for the entirety of their career.

Meeting the educational needs of this generation that differs so much from predecessors requires a classroom approach that differs as well. Classrooms that refuse to adopt change from previous teaching methods are not addressing the needs of students whose skill sets and skill development needs are evolving to include information technology (Hawkins, 2002). Millennial learners are multitaskers that are "active and independent learners" (Resnick, 2002) who, according to Dede (2005) fall into an entirely different learning style. "Neomillennial Learning Styles" are outlined by Dede (2005) and are shaped by experiential learning and social constructivist learning. Because of the technology that surrounds millennials they are often comfortable using many kinds of media to achieve the desired outcome and often learn in a very individualistic fashion that allows them to personalize their learning (Dede, 2005). Experience is key to millennial learners as they often succeed in active or inquiry based learning which allows them to think critically in order to solve a problem and then reflect on their solution. Providing educational experiences for students allows them to make connections across experiences and seek knowledge and understanding on their own interest through those experiences (Dede, 2005). Educators can benefit from these experience-driven learning styles by incorporating the technology that millennial students already use on a daily basis into classroom learning and in turn, create a learning experience that follows students throughout their lives, anywhere they go (Resnick 2002).

Student engagement and active learning are perpetual goals that instructors strive for on a daily basis. The learning method of inquiry-based instruction (analogous to problem-based instruction) combines the structure of scientific inquiry with hands-on learning while placing the student in a leadership role within their own learning. Inquiry-based instruction is one in which the teacher acts as a facilitator of learning, guiding students to solve problems through critical thinking and application of content concepts to real world issues (Thoron & Myers, 2012). Based on numerous pedagogical theories, inquiry-based instruction works in a constructivist fashion, with a hands-on focus that puts the student at the center of the learning method (Parr & Edwards, 2004). Inquiry-based instruction is common in secondary agriculture education, creating authentic learning experiences that motivate students to grow as leaders in their own learning processes while developing skills and knowledge in the agricultural realm. Parr, et.al., (2004), stated agriculture has historically included hands-on instruction, and allows teachers to cover a vast array of topics while connecting them all in a way that students can grasp. Thoron (2012) indicated that students who received inquiry-based instruction were better able to "link evidence with claims" and had "stronger argumentation skills" that better prepared them for college and careers, as opposed to students who did not receive inquiry-based instruction (p.65). Linking evidence with claims is also a foundational concept of science instruction which allows the marrying of science and agriculture topics to create a more enriching curriculum for students.

Curriculum Shifts

Developing curriculum that is relevant for students is imperative to their success in the classroom as well as in post-secondary education and careers. The National Research Council Board on Agriculture (1998) reported the need to update agriculture education curriculum and encouraged instructors to maintain progress within the classroom that matched the progress occurring in the industry itself. While slow to respond, agricultural educators began incorporating more technical science and technology concepts into curriculum, thus marking the transition towards "Agriscience", a blended agriculture and science (Boone et. al., 2006). Including biotechnology, physics, chemistry and other science topics in agricultural content created the opportunity for agriculture classes to be recognized as a science credit, allowing students more freedom to fulfill graduation requirements with classes that fit their interests. The need to incorporate biotechnology into agriculture curriculum was met by hesitation from teachers who felt they lacked adequate competence on the subject (Boone, et. al., 2006). This incorporation created a need for professional development and resource availability in order for teachers to properly meet the changing curricula needs of their students and administrations.

Ramsey and Edwards (2011), stated the importance of matching skills instilled in students to industry standards is stressed, noting the change in skill sets required in the agriculture industry today to include technology, information systems and a more global mindset. To recognize the skills that are needed to be successful in agriculture careers today, Agriculture, Food and Natural Resources (AFNR) standards were developed to help teachers design relevant curriculum. These standards provide pathways for students that prepare them for specific elements of careers in the agriculture industry. Skills necessary for career success that include science and technology will continue to shape the needs of agriculture education curricula as the agriculture industry itself continues to change and grow (Dailey, Conroy & Shelley-Tolbert, 2001). Resnick (2002) suggests change to how these skill-building topics are taught and states that "instead of dividing up the curriculum into separate disciplines, we should focus on the themes and projects that cut across the disciplines, taking advantage of the rich connections among different domains of knowledge" (p.36).

Science, Technology, Engineering, and Mathematics

Science, technology, engineering, and mathematics (STEM) were identified as priority areas of education by global leaders as well as the federal government. Funding for education and incentives for STEM programming became quite competitive and caused the burst of partnerships between schools and government agencies, industry companies and many other interested entities (Breiner et. al., 2011). The National Science Foundation was instrumental in the development of the term "STEM", and in the governmental policy surrounding educational reform that hopes to encourage students to pursue careers in STEM areas. In the early 21st century, STEM was growing on a global scale and the United States of America began drafting education-focused legislature to offer incentives for schools to implement STEM into curriculum (Breiner et. al., 2011). STEM concepts were commonly being taught as separate subjects, but the STEM movements were pushing for the subjects to be taught as interconnected topics that naturally worked together. Inquiry-based instruction was highlighted as a successful teaching tool that worked well with STEM lessons (Breiner et. al., 2011). The foundation of teaching core content areas in a way that allowed students to apply concepts in the real world is one that parallels the structure of agriculture education. Stubbs and Myers (2016), utilized teacher interviews to confirm that agriculture education has always been focused on providing applicable education through connecting content areas through hands-on experiences. Since 1929 technology and engineering have been incorporated within agriculture and this incorporation has evolved to include precision agriculture technology. Utilizing agronomy, animal sciences, biology and soil science, needs and problems within production agriculture can be identified. The solution to solving the problems associated with production agriculture will include mathematics and engineering for the development of technology that may not have previously existed.

Precision Agriculture Overview

Historically, agriculture is derived from hunter-gatherers who then utilized information they learned about plants and animals to develop a reliable and controllable food source. Applying information to farming practices in order to increase yields has been constantly repeated over time and has now evolved to include the available technology of the modern era. Utilizing technology to collect data about their fields and crops gives farmers access to information that allows them to customize their farming practices (Lowenberg-DeBoer, 2015). Each field can be treated as an individual to precisely maximize productivity, noting the use of the word "precision" agriculture. To fully understand the importance of teaching precision agriculture technology concepts in classrooms there must be an established understanding of the technology itself. The foundational ideas of precision agriculture include utilizing information gathered by technology such as sensors, monitors, and imaging to make management decisions that maximize farm efficiency and profits with minimal inputs. Zhang, et. al., (2002), discuss the variability that exist in yield, soil, fields, crops, crop damage, and management and how precision agriculture could potentially manage that variability.

The scope and width of precision agriculture technologies that exist, at least in the development stages, are limitless. Technology developers push the physical limits of engineering and technology specifically focusing on agronomy with the goal of solving problems or streamlining processes in agriculture. Companies focused on producing technology for farmers are growing with the popularity of precision agriculture. Industry leaders such as Agribotix, John Deere, Trimble, Granular, Climate Corporation, 360 Yield and Farmobile (Grassi, 2015) investigate and promote the use of yield maps, sensors, variable rate planting and application, and monitoring systems. The most important challenge posed to precision agriculture technology as a whole is the integration into day-to-day farming operations and "becoming a part of the normal farming process" (McBratney et. al., p.13, 2005).

Yield mapping is popular among farmers as it provides valuable information which they can base cost-saving decisions on and is easy to use with the appropriate equipment that has recently become standard issue (Wright et. al., 2003). The yield map that results provides farmers with an easy to read map of each of their fields, giving those farmers information regarding their crops production in response to a variety of farming practices, soil types and weather circumstances (Lowenberg-DeBoer 2015). Batte and Arnholt, (2002) conducted case studies focusing on six well-known and respected farmers who were considered early adopters. Of the farmers in the study, it was found that precision agriculture technology that provides information (yield monitors, soil mapping, etc.) were preferable to farmers than variable rate applications (2002). Farmers can use yield maps to make decisions about fertilizers, chemicals, seed type, insurance coverage and claims, tillage, drainage practices and much more. By observing and learning from their peers use of technology, farmers have been better able to understand and apply precision agriculture technology to their own operations.

Precision Agriculture Adoption Among Farmers

The adoption of emerging technology can often be seen as a risky investment of capital causing a delay from the time the technology becomes available to adoption. The adoption process often resembles a bell curve over time with early adopters making up 13%, early majority adopters 34%, late majority adopters 34%, and laggards 16%. Motivation to adopt technology is a common denominator among early adopters. The most common motivating factors are profitability, lower input cost, farm management information and environmental compliance. Factors of adoption can also include, such as education, farm size, age, and others (Daberkow & McBride, 2003). The implementation of education and training in emerging technologies has a direct impact on the success of the technology, because as the average age of farmers increases, they are less likely to adopt new technologies without feeling comfortable with the technology first. In order to utilize new tools, they need to be confident in their ability to use and learn the new technology (Adrian, et. al 2005). Feder and Umali (1993), discuss the adoption diffusion process in relation to technology over time, emulating that farmers' built in uncertainty or skepticism of change is affected by people in their network and their experiences with the technology in question may cause farmers to incorporate elements of the technology rather than the entire concept all at once. The idea of later adopters who observe early adopters' success or failure with emerging technologies institutes an "unconscious process of learning" that occurs in an informal way, as opposed to formal learning in a training class or other educational settings that are less popular among farmers (Feder & Umali, p. 220, 1993).

Providing informal educational opportunities like field days and seminars for farmers to learn about the products they are considering implementing is an important way for precision agriculture companies to communicate the benefits of their product directly (Heiniger, Halvin, Crouse, Kvien, & Knowles, 2002). The formal education level of farmers also plays a role in their eagerness to adopt technology. A study conducted on producer perceptions by Adrian, et al. (2005) found that farmers who hold higher levels of education are more likely to adopt new technology earlier than their counterparts.

Chapter III
Methods

Background

The survey instrument was developed by the researcher to gather information from teachers in order to identify the current state of precision agriculture technology incorporation into agriscience education classes. Members of the National Association for Agricultural Education in the states of Alabama and Illinois were identified as the population ($N = 693$) for this study. The intent of this study was to gather foundational information regarding the extent of precision agriculture technology inclusion in secondary agriculture classrooms on which future research could focus and expand. The survey instrument was developed with that intent in mind. Teachers are asked not only whether or not they teach precision agriculture technology concepts, but how they include those topics or what barriers prevent them from doing so. The instrument also evaluated teacher perceptions related to the future importance of precision agriculture technology in a variety of areas including their classroom, their coursework, the agriculture industry, and agriculture career field. A pilot test was conducted to identify potential areas of weakness within the instrument, and appropriate changes were made to reflect the results of the pilot test. Changes included the sequencing of questions, adjustments to syntax and inclusion of demographic indicators. The instrument was created based on the culmination of ideas set forth by previous researchers, whose frameworks guided the study.

Conceptual Framework

The conceptual framework for this study is built upon a combination of two theories, Diffusion of Innovation Theory (2003) and the Theory of Planned Behavior, (1975). First, Rogers' Diffusion of Innovation theory describes the spreading of new ideas and the uncertainty that surrounds adoption of those new ideas (Rogers 2003, Sahin 2006, Surry 1997). The diffusion of innovation theory is comprised of four main components; innovation, communication channels, time and a social system (Rogers 2003). The innovation element of the diffusion of innovation theory is made up of the ideas that are becoming relevant, whether or not they are considered to be new or emerging. Technology concepts are often innovative ideas and follow the diffusion of innovation theory as people develop new ways to utilize technology. Communication channels are characterized as the process of sharing information or the spreading of innovations and ideas. Rogers (2003) discusses how homophily and heterophily affect the spread of ideas, stating that ideas flow more freely among homophilous individuals, or individuals who are similar in a variety of ways and work together towards similar goals. Heterophilous individuals tend to be quite different from each other and therefore have a more difficult time communicating and agreeing on the importance of ideas and innovations. Time is considered by Rogers (2003) to be the measurement tool of the entire process of learning about innovations to adopting them. The innovation-decision process consists of an individual's course of learning over time that begins with learning of an innovation, learning about the innovation, forming an opinion on the innovation and results in either adoption or rejection of the innovation (2003). Social systems are the final component of Rogers' diffusion of innovation theory. Social systems can be characterized as networks of individuals or units working together to accomplish a common goal, often groups of people or organizations. The leadership of some individuals or the normality of the group affect the flow of information and how it reaches individuals (Rogers 2003). This element shares many characteristics with the idea of human capital, which describes how individual's professional and personal networks affect their decision-making process (Hunecke, Engler, Jara-Rojas, & Poortvliet, 2017).

Rogers' diffusion of innovation theory develops the process of innovation adoption and describes how groups of individuals within a social system can be identified based on the time it takes them to adopt innovations, and the attributes that commonly affect their decision-making process. These categories are innovators, early adopters, early majority, late majority and laggards (Rogers 2003). The first group to adopt are called innovators, described as individuals who are comfortable with uncertainty and are capable of higher-level thinking in regards to concept application. Early adopters are characterized as being slightly more contemplative than innovators, are led by their opinions on the innovation and evaluate the innovation subjectively. The individuals that comprise the early majority group are often willing to adopt innovations, but rarely lead the way. They often take longer than both innovators and early adopters to contemplate adoption of innovations, often looking to their predecessor adopters for signs of success. Late majority adopters are cautious by nature and rely heavily on social norms to sway their decisions, they require little to no uncertainty surrounding the innovation in question. Laggards are the last group of units or individuals to adopt innovation. Laggards resist innovation adoption and often doubt the success of an innovation, exercising acute caution in the decision-making process (2003).

The attributes and attitudes of innovation adopters described in Rogers' (2003) Diffusion of Innovation theory are similar to the characteristics that influence decisions, intentions and behaviors described in Fishbein and Ajzen's (1975) theory of planned behavior. Fishbein and

Ajzen (1975) stated that an "individual's intention to perform a behavior (behavior x) is influenced by their attitudes towards that behavior as well as their beliefs about the consequences of that behavior" (p.16) Intention to perform a behavior (behavior x) is also influenced by subjective norms and normative beliefs about that behavior (Fishbein & Ajzen 1975). The confluence of these theories consider behavior x to be the adoption of an innovation or idea. For this example, the innovation or idea is the incorporation of precision agriculture technology concepts which utilize STEM structures into secondary agriculture education coursework. Adopting this idea implies the consequence of the instructor updating curricula and learning new concepts, which is undesirable to late adopters and laggards, therefore they are resistant to the innovation and less likely to perform behavior x, which is in this example the adoption or incorporation of precision agriculture technology concepts into coursework. The individuals are influenced by their attitudes and beliefs towards adopting new innovations (Fishbein and Ajzen 1975). A similar example could be found with the opposite result, utilizing an innovator or early adopter as the instructor or individual. This individual's attitudes and beliefs towards adopting new ideas are positive, therefore they are more likely to incorporate precision agriculture technology into their coursework.

Key Characteristics of the Study

Precision agriculture concepts have historically been a cornerstone of agricultural education curricula but little research has been conducted to evaluate the specific barriers, concepts, demographics, and confidence teachers possess in precision agriculture. Characteristics of this study represent practicing agricultural education teachers in Alabama and Illinois who are representative of their peer groups. This study addressed specific objectives to evaluate practicing teachers perceptions and inclusions of precision agricultural curriculum.

Purpose of the Study

The purpose of this study is to observe the curriculum involving precision agriculture technology that is currently taught, and gain insight into secondary agriculture education teachers' decisions of why they choose to integrate these topics or not. By understanding what is currently being taught by secondary agriculture education teachers, researchers may then be able to better provide opportunities for growth through professional development opportunities, industry network connections and educational workshops to encourage the incorporation of precision agriculture technology into curriculum. This incorporation must occur in order to keep secondary agriculture education relevant and in tune with industry trends that ultimately affect the careers of agriculture education students.

Objectives of the Study

The specific objectives of the study were to:

1. Describe the courses and curriculum currently being used to teach precision agriculture concepts;
2. Describe participants by their personal characteristics and their incorporation of precision agriculture concepts in their classrooms;
3. Describe the relationships between participant personal characteristics and their incorporation of precision agriculture concepts in their classrooms;
4. Describe participants by importance and competence with respect to teaching precision agriculture;
5. Describe the barriers teachers identify that prevent them from teaching precision agriculture;

6. Describe the most important topics in precision agriculture and the relevance of precision agriculture in the areas of education and agriculture; and
7. Define the term precision agriculture.

Human Subjects Review

Auburn University policy requires that any research project using human subjects must be reviewed and approved by the Office of Research Compliances (ORC) Institutional Review Board (IRB). This protocol is in place to protect the human subjects involved in research conducted by Auburn University and to follow state and federal regulations regarding research practices. In compliance with Auburn University policy, this study was properly reviewed and was approved by the IRB to proceed with research efforts. The IRB assigned the number 17-141 EX 1704 to this project.

Study Design

Instrumentation. The review of existing literature indicated an instrument combining the diffusion of innovation and planned behavior theories focusing on identifying the adoption of innovative course content in secondary education did not exist. The researcher and others developed the initial survey instrument based on research in education journals, science journals and combine the foundational concepts of the diffusion of innovation theory (Rogers 2003), the theory of planned behavior (Fishbein & Ajzen 1975), social learning theory (Bandura 1977) and needs assessment model (Borich, 1980).

The instrument was developed with the purpose of identifying each participant's level of incorporation of precision agriculture technology concepts. Development of the questionnaire instrument was initially completed by the researcher, two academic faculty in the agriscience education field, and an agriculture and natural resources extension agent. During the development and design of the instrument, fifteen items were selected. Eighteen items were then selected to collect demographic data. Figure 1 depicts the framework of the questionnaire instrument which allowed data to be collected from each participant regarding details of their choice of whether or not to incorporate precision agriculture concepts. Eight total statements were developed and distributed between the participants indication of their incorporation or lack thereof, allowing each participant to respond to four similarly founded statements. Participants indicated their incorporation of the conceptual statements focused on the following areas: identification of courses in which they currently incorporate precision agriculture technology concepts, topics within precision agriculture technology that are most commonly incorporated, instructor perceptions towards the most important topics in precision agriculture technology, and identification of classroom and curriculum resources that are most utilized. For participants who claim not to incorporate precision agriculture technology concepts, statements focused on the following areas were constructed: perceived barriers that prevent the incorporation of precision agriculture technology concepts into curricula, identification of classroom and curriculum resources that are most utilized, measurement of most important reasons for not incorporating precision agriculture technology concepts, and perception of most important topics in precision agriculture technology.

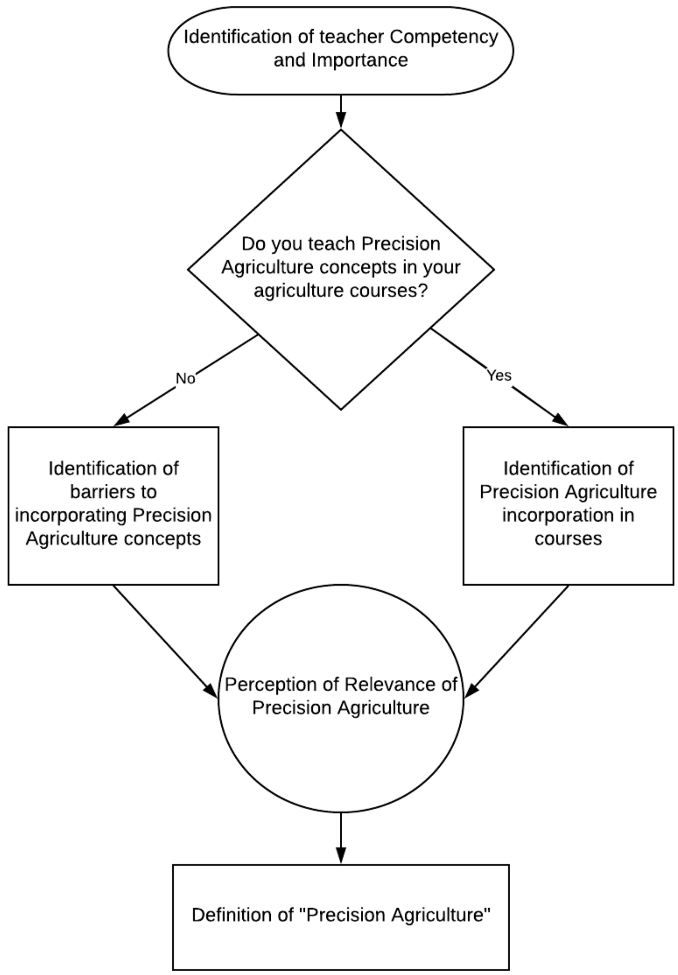

Figure 1

Construction of the Survey Instrument. An exhaustive review of research revealed no current instrument which would appropriately address the research questions developed for this study. Therefore, the instrument was developed using existing literature in curriculum and development, technology use in classrooms, agricultural education content areas, and pilot study data representative of the population being investigated. The researcher designed the instrument specifically to collect data relevant to each individual teacher that would allow for the analysis and comparison of data between teachers who incorporate precision agriculture concepts into their coursework and those who do not.

Pilot Test. Eight individuals were selected to participate in a pilot test. These eight individuals were representative of the population, but were not included in the sample of the population utilized for the study. The individuals selected to provide feedback in the pilot test were selected by the researcher based on their knowledge of research and their likeliness to provide honest, applicable input. On August 30th, 2017, a link to the survey instrument was sent via email to five secondary high school agriculture teachers in Illinois and three teachers in Alabama. These teachers were asked to review the instrument and provide input on the potential ambiguity of statements, sentence structure and other changes that may be necessary. Results from the pilot test indicated a few necessary changes to the instrument, which were promptly made by the researcher and approved by the committee chair prior to survey distribution.

Research Participants

Population. The subject population consists of certified secondary agriculture educators in Alabama and Illinois who are members of the National Association for Agricultural Educators. The membership roster from the states of Alabama ($N=302$) and Illinois ($N=391$) will be used as the populations for the study. With this population, Cochran's statistic will be used to determine sample size which ensures an equal sampling distribution for Alabama ($n=169$) and Illinois ($n=196$).

Oversampling by twenty percent will be used to account for non-respondents by initiating replacement surveys. 373 total surveys were sent out to the sample. Using Lindner, Murphy & Briers' method 3, analysis and comparison of early versus late respondents was conducted using a *t-test* to identify any significant differences between timing and data results (2001). Table 1 shows the resulting lack of significant differences between respondents and non-respondents.

Table 1

Comparison of respondent and non-respondents by statements

Statement*	*t*	*df*	*Sig 2-tailed*
Competence	1.49	86	.14
Importance	0.26	86	.80
Incorporation of Precision Ag	0.00	86	1.00
Relevance of Precision Ag in Classroom Technology	0.70	80	.48
Relevance of Precision Ag in Coursework/Content	0.82	80	.42
Relevance of Precision Ag in Agriculture Industry	0.75	80	.45
Relevance of Precision Ag in Agriculture Job Market	1.64	79	.11

*Statements selected based on their overall representation of the instrument

Selection of Research Participants. The potential population for this study were representative of certified agriculture teachers in Alabama and Illinois. Participants were identified using a contact data base provided by the professional agricultural education organizations in each state. The total sample was determined through Cochran's analysis for appropriate sample size. The use of Cochran's Theorem (1977) provides assurances that the sample is representative of population being investigated. Non-response bias was addressed through oversampling of the population. Participants were randomly selected from each population until the sample size was complete.

Proposed analysis of the study

The analysis of data for this study utilized descriptive statistics for describing the sample demographics in each state. This type of analysis is appropriate for this study as participants should be described based on their characteristics to further explain the outcomes of the research. Borich analysis was implemented to measure participants confidence and level of importance related to precision agriculture concepts. This analysis is an appropriate measure of a participants need for further training and served as an indicator of their willingness to include precision agriculture in their curriculum. Theme analysis identified common phrases participants used to describe their definition of precision agriculture and the barriers that prevent the instruction of precision agricultural concepts. The analysis of the definitions was conducted by a committee of academic experts. A blind analysis defined the scope of this review as each committee member was unaware of other researcher's analysis of the data. The researcher of this study evaluated the comments from the committee independently, constructed the definition, and provided a finalized description to the committee. This analysis allows for inter-rater reliability between participants while reducing potential researcher bias. To further understand if a relationship exists between observed categorical values and theoretical expectations, a Chi Square for Goodness of Fit analysis was conducted.

Chapter IV
Data Analysis and Findings

Introduction

The purpose of this study was to identify the curriculum involving precision agriculture technology that is currently taught and to gain insight into secondary agriculture education teachers' decisions of whether or not they chose to integrate precision agriculture topics in their agriculture curriculum. Through the investigation of curriculum currently being used, it was decided by the researcher that deeper understanding of teachers and their decision making processes could be found in the data collected. Those findings are presented here and have been organized to match the objectives they most closely represent.

Study Design

The survey instrument was developed by the researcher and was used to identify whether or not teachers chose to incorporate precision agriculture technology concepts into their curriculum and to investigate details as to how it is currently integrated or why teachers choose not to integrate precision agriculture concepts. The survey instrument also gathered teacher perceptions on precision agriculture itself, the most important topics within precision agriculture and the perceived future relevance. Data was collected during the 2017-2018 academic year from secondary agriculture teachers in Alabama and Illinois. A *t-test* was conducted to identify any significant difference in data collected from respondents and non-respondents, but no significant differences were found.

Analysis by Study Objective

Objective 1: Describe the courses and curriculum currently being used to teach precision agriculture concepts.

Courses which contain units or lessons pertaining to precision agriculture

Participants who indicated their incorporation of precision agriculture concepts were asked to identify courses they teach which contain units or lessons pertaining to precision agriculture. Table 2 presents the results showing that 61% of the teachers who incorporate precision agriculture concepts in their courses do so in an Introduction to Agriculture course, 30% in Horticulture courses, 18% in Animal Science courses, 30% in Ag Mechanics courses, 18% in Ag Construction courses, 36% in Agribusiness courses, 9% in Forestry courses, 5% in Aquaculture courses, 11% in Agricultural Leadership courses, 2% in Cooperative Classes, and 30% selected Other courses. The "other" courses were identified by respondents as Agronomy, Ag Science, General Agriculture, Plant Biology, Ag Sales and Marketing, PSAA, Crop and Soil Science, and Advanced Agriculture.

Table 2

Courses taught which contain units or lessons pertaining to precision agriculture

Courses in Agriculture Classrooms	*f*	%[1]
Introduction to Agriculture	27	61
Agribusiness	16	36
Horticulture	13	30
Ag Mechanics	13	30
Other	13	30
Animal Science	8	18
Ag Construction	8	18
Agricultural Leadership	5	11
Forestry	4	9
Aquaculture	2	5
Cooperative Class	1	2

[1]Percent of teachers who incorporate precision agriculture concepts in their classroom.

Curriculum resources currently used by teachers in their agriculture classrooms

Participants indicated the resources they most often use in their curriculum planning, the results are shown in Table 3. Of the teachers who indicated their incorporation of precision agriculture concepts in their curriculum, 22% use Purchased or Packaged Curriculum, 59% use Self-Created Curriculum, 32% use Textbooks, 52% use Online Resources, 4% use Simulators, 45% use Hands-On Technology, and 6% indicated the use of "Other" resources. Of the teachers who indicated they *do not* incorporate precision agriculture concepts into their curriculum, 38% use Purchased or Packaged Curriculum, 59% use Self-Created Curriculum, 38% use Textbooks, 65% use Online Resources, 9% use Simulators, and 59% use Hands-On Technology.

Table 3

Curriculum resources used by teachers in agriculture classrooms by teacher incorporation

	Incorporate Concepts		Do Not Incorporate Concepts	
Resources[1]	*f*	%[1]	*f*	%[1]
Self-Created Curriculum	26	59	26	59
Online Resources	23	52	29	65
Hands-On Technology	20	45	26	59
Textbook	14	32	17	38
Purchased/Packaged Curriculum	10	22	17	38
Simulators	2	4	4	9
Other	3	6	0	0

[1] Percentages calculated from total number of teachers who indicated their incorporation of precision agriculture concepts.

Objective 2: Describe participants by their personal characteristics and their incorporation of precision agriculture concepts in their classrooms.

Personal Characteristics

Of the secondary agriculture teachers who participated in this study, the following demographic data was collected and is shown in Table 4. The study was conducted in two states, resulting in 50.7% of participants teaching in Alabama and 49.3% in Illinois. The participating teachers were 73.2% male and 26.8% female. Teachers described the enrollment numbers for their agriculture education programs and indicated: 7.4% (20-40 students), 14.8% (40-60 students), and 77.8% (60+ students). Of those students enrolled in agriculture education programs, teachers indicated the number of students who were also FFA members: 7.4% (1-20 students), 25.9% (20-40 students), 25.9% (40-60 students), and 40.7% (60+ students). Teachers identified the location of their schools as 84.1% rural, 14.6% suburban and 1.2% urban. The most common type of agriculture in the area surrounding each teachers' school was 67.8% row crop, 59.6% livestock or animal production, 7.1% fruit production, 4.0% dairy, and 13.1% indicated other agricultural products of 4.0% forestry, 5.1% nursery or horticulture, 1.0% aquaculture, 2.0% poultry and 1.0% swine.

Participating teachers indicated their receiving a Bachelor's degree or higher. Teachers indicated their highest degree earned, with 50% indicating Bachelor's degree, 46.3% Master's degree, 3.7% Specialist degree. No teachers indicated having earned a doctorate. Teachers identified their age ranges as: 11.3% (18-24 years old), 32.5% (25-34 years old), 21.3% (35- 44 years old), 20% (45-54 years old), and 15% (55-64 years old). No participants identified themselves as over 65 years old. Teacher longevity self-identified by teachers indicated: 26.8% (0-5 years teaching), 25.6% (6-10 years teaching), 19.5% (11-20 years teaching), 22% (21-30 years teaching) and 6.1% (30+ years teaching).

Table 4

Description of Participants by Personal Characteristics

Personal Characteristics		*f*	%
In which state do you currently teach?[1]			
Alabama		37	50.7
Illinois		36	49.3
	Total	73	100
What is your gender?[2]			
Male		60	73.2
Female		22	26.8
	Total	82	100
How many students are currently enrolled in your agriculture program?[3]			
60+		63	77.8
40-60		12	14.8
20-40		6	7.4
1-20		0	0
	Total	81	100
How many of your enrolled students are FFA members?[4]			
60+		33	40.7
20-40		21	25.9
40-60		21	25.9
1-20		6	7.4
	Total	81	100
Which description best identifies the location of your school?[5]			
Rural		69	84.1
Suburban		12	14.6
Urban		1	1.2
	Total	82	100

Table Continued On Next Page

Table 4 Continued From Previous Page

Personal Characteristics		*f*	%
What is the most common type of agriculture in your area?			
Row Crop		67	67.8
Livestock/Animal Production		59	59.6
Fruit Production		7	7.1
Dairy		4	4.0
Other		13	13.1
Nursery/Horticulture		5	5.1
Forestry		4	4.0
Poultry		2	2.0
Aquaculture		1	1.0
Swine		1	1.0
	Total	99	100
What is the highest degree you earned?[6]			
Bachelor's Degree		41	50
Master's Degree		38	46.3
Specialist Degree		3	3.7
High School Diploma or Equivalent		0	0
Associate's Degree		0	0
Doctorate		0	0
	Total	82	100
What is your age?[7]			
25-34		26	32.5
35-44		17	21.3
45-54		16	20
55-64		12	15
18-24		9	11.3
65-74		0	0
75 years or older		0	0
	Total	80	100
How many years have you been teaching?[8]			
0-5		22	26.8
6-10		21	25.6
21-30		18	22
11-20		16	19.5
30+		5	6.1
	Total	82	100

[1]twenty-six participants did not indicate their teaching location.
[2]seventeen participants did not indicate their gender.
[3]eighteen participants did not indicate their current enrollment.
[4]eighteen participants did not indicate their FFA enrollment.
[5]seventeen participants did not indicate the location of their school.
[6]seventeen participants did not indicate their highest degree earned.
[7]nineteen participants did not indicate their age.
[8]seventeen participants did not indicate their number of years teaching.

Incorporation of precision agriculture concepts in their classrooms

Teachers participating in the study were asked to identify whether or not they incorporate precision agriculture concepts in their classrooms. Table 5 shows the results from the study, where 50% of participants indicated "yes" they do incorporate precision agriculture and 50% indicated "no" they do not.

Table 5

Participants' Incorporation of precision agriculture concepts

Incorporation*	*f*	%
Yes	44	50
No	44	50
Total	88	100

*11 participants did not indicate their incorporation of precision agriculture concepts

Objective 3: Describe the relationships between participant personal characteristics and their incorporation of precision agriculture concepts in their classrooms.

A chi-square goodness of fit test was used to identify any relationships that may exist between the participants' personal characteristics and their decision to incorporate precision agriculture concepts into their curricula. A significant relationship would signify that a personal characteristic would have an effect on their decision to incorporate precision agriculture. The results of this study, as shown in Table 6, are that there are no significant relationships between participant personal characteristics and their decision to incorporate precision agriculture concepts into their curricula.

Table 6

Contingency table by personal characteristics and incorporation of precision ag concepts

Personal Characteristics	*n*	*df*	*Sig*
Age	80	4	.91
Years Teaching	82	4	.87
Gender	82	1	.79
State	73	1	.72
Education	82	2	.42
School Location	82	2	.34
Student Enrollment	81	2	.13

Objective 4: Describe participants by importance and competence with respect to teaching precision agriculture

Teachers were asked to self-identify the importance as well as their own competence in teaching precision agriculture concepts in their classrooms on a scale from 1 to 5, with 5 being the most important or most competent. This question is based on Borich's (1980) model for identifying and assessing areas of need, and in this case, the need for professional development. Table 7 shows the differences between the mean importance (4.49) and competence (3.36).

Table 7

Participants perception of importance and competence in teaching precision agriculture

	n	*M*	*SD*
Importance*	88	4.49	0.55
Competence*	88	3.36	1.00

*12 participants did not indicate their perception of importance and competence.
M=Mean, SD=Standard Deviation

Objective 5: Describe the barriers teachers identify that prevent them from teaching precision agriculture

Teacher participants were asked to provide their rationale for not incorporating precision agriculture concepts in their classroom by describing the barriers that prevent them from doing so. The descriptions provided by respondents provided a qualitative measure for evaluating the individuals and the group as a whole. Participant statements were evaluated for similarities and differences in the language of the respondents allowing deeper understanding of the most common barriers that prevent teachers from incorporating precision agriculture into their classrooms. In order to provide an accurate representation of the open-ended responses provided by the participants, a thematic analysis was performed. During the thematic analysis, a group of researchers evaluated statements individually and then collectively to account for inter-rater reliability.

Thematic analysis provided the researcher with five major categories that were identified by teachers as the most common barriers to teaching precision agriculture concepts. The aforementioned categories include Funding, Equipment, Curriculum, Experience and Professional Development.

Funding. Teachers who identified funding as a barrier to incorporating precision agriculture concepts into their classrooms described their lack of access to funding, their inability to invest the necessary money into the materials and supplies, as well as the high cost of the technology itself.

Equipment. The equipment used in precision agriculture exists in simulators and learning tools that can be used in classrooms. Teachers identified a lack of access to this equipment and the overall cost of the equipment as another barrier to incorporating related concepts into their classrooms.

Curriculum. Secondary teachers use lesson plans and curriculum built around the topics they teach in their classrooms. The teachers who participated in this study identified a lack of curriculum that exists on the topic of precision agriculture as a barrier to incorporating precision agriculture into their classrooms. Teachers also indicated that in order to teach precision agriculture, they would have to update or re-align their curriculum. Still other teachers stated they felt that precision agriculture concepts didn't align with their current curriculum or their standards for teaching. One teacher indicated that "precision ag is not currently part of a state or national [FFA] CDE", and many teachers design their course materials around CDE's.

Experience. Teachers identified a lack of experience with precision agriculture in general. Precision agriculture is a fairly emergent and progressive content area, and some teachers felt they lack experience with the technologies and concepts. One of the teachers responded "even if you learn the subject to teach, it seems outdated almost immediately". The learning curve associated with the technology, according to the teachers, is nearly impossible to keep up with.

Professional Development. Understanding their lack of knowledge on the subject of precision agriculture, teachers recognized the need for professional development that would improve their knowledge. The lack of professional development and teacher training was identified as another barrier to teachers' incorporation of precision agriculture. Professional development allows teachers to become familiar with content and learn about curriculum resources that could be used to teach the content, and the teachers in this study recognized the need for more teacher training in precision agriculture.

Objective 6: Describe the most important topics in precision agriculture and the relevance of precision agriculture in the areas of education and agriculture.

Most important topics in precision agriculture

Teacher perceptions of the most important topic in or involving precision agriculture were gathered from all participants and are displayed in Table 8 by whether or not they incorporate precision agriculture concepts in their classrooms. Teachers who indicated their incorporation of precision agriculture in their classrooms identified the most important topics in precision agriculture as: 20.9% (GPS), 14.0% (Variable Rate Technology), 0% (Satellite Imaging), 20.9% (Soil Sampling or Land Management), 9.3% (Yield Monitoring), 4.7% (Automated Production Systems), 4.7% (Unmanned Aerial Systems or Vehicles), 23.3% (Genetic Modification), 2.3% (Chemical Technology). Teachers who indicated they did not incorporate precision agriculture in their classrooms identified the most important topics in precision agriculture as: 28.9% (GPS), 10.5% (Variable Rate Technology), 5.3% (Satellite Imaging), 18.4% (Soil Sampling or Land Management), 5.3% (Yield Monitoring), 5.3% (Automated Production Systems), 5.3% (Unmanned Aerial Systems or Vehicles), and 21.1% (Genetic Modification). None of the teachers who did not incorporate precision agriculture concepts in their classrooms identified Chemical Technology as the most important topic.

Table 8

Most important topics in precision agriculture by teacher incorporation of precision agriculture concepts

Most Important Topics in Precision Ag[1]	Incorporate Concepts *f*	Incorporate Concepts %	Do Not Incorporate Concepts *f*	Do Not Incorporate Concepts %
Genetic Modification	10	23.3	8	21.1
GPS	9	20.9	11	28.9
Soil Sampling/Land Management	9	20.9	7	18.4
Variable Rate Technology	6	14.0	4	10.5
Yield Monitoring	4	9.3	2	5.3
Automated Production Systems	2	4.7	2	5.3
Unmanned Aerial Systems/Vehicles	2	4.7	2	5.3
Chemical Technology	1	2.3	0	0
Satellite Imaging	0	0	2	5.3
Other	0	0	0	0
Total	43	100	38	100

[1]eighteen total participants did not indicate their perceived most important topic in precision ag.

Relevance of precision agriculture in the areas of education and agriculture

The teachers in this study were asked to identify their perception of the future relevance of precision agriculture topics across the areas of education and agriculture. Teachers were given four statements that each pertained to either education within their classroom or to the field of agriculture. They were asked to indicate their opinion of relevance 5-10 years in the future on a scale from 1-5, where 5 – "Extremely Relevant", 4 – "Somewhat Relevant", 3 – No Change in Relevance from Today, 2 – "Somewhat Irrelevant", and 1 – "Extremely Irrelevant". Table 9 shows teachers indicating their perceptions of precision agriculture as overwhelmingly relevant in their classroom technologies, in their coursework/content, in the agriculture industry and in the agriculture job market. In their classroom technologies, 96% of teachers indicated that precision agriculture topics were either "extremely relevant" or "somewhat relevant". 95% of teachers indicated that precision agriculture topics were either “extremely relevant” or “somewhat relevant” in their coursework/content. 100% of the teachers who participated in this study indicated that precision agriculture topics were either “extremely relevant” or “somewhat relevant” in both the agriculture industry and the agriculture job market.

Table 9

Participants perception of future relevance of precision agriculture topics

	Extremely Relevant		Somewhat Relevant		No Change in Relevance from Today		Somewhat Irrelevant		Extremely Irrelevant	
Areas of Relevance	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%
In Your Classroom Technologies	46	56	33	40	3	4	0	0	0	0
In Your Coursework/Content	35	43	43	52	4	5	0	0	0	0
In The Agriculture Industry	72	88	10	12	0	0	0	0	0	0
In the Agriculture Job Market	61	75	20	25	0	0	0	0	0	0

Objective 7: Define the term precision agriculture.

In similar fashion to objective 5, a thematic analysis was performed on the open-ended responses of the teachers in this study to form a cumulative definition of precision agriculture as perceived by secondary agriculture teachers. A group of researchers evaluated the statements provided by respondents both individually and collectively to account for inter-rater reliability. Teachers were asked to provide the researcher with their individual definition of precision agriculture, which allowed researchers to see each teacher’s understanding of the term “precision agriculture” and further how they understand the role of precision agriculture in the agriculture industry and in their classroom. A list of “key terms” was compiled by the researcher and was then used to create a common definition representative of the participants’ responses.

The “key terms” include; using, technology, agriculture, production, yields, farming, data, efficiency, productivity, increase, management, precise, and information. From this list of key terms, the following definition was composed, representing the opinions of secondary agriculture educators.

“Precision agriculture is the use of agricultural technologies to make precise, data-based management decisions that increase efficiency and productivity in agriculture.”

Summary of Findings

The findings of this study present an in-depth look at secondary agriculture teachers’ response to the recent industry boom in precision agriculture. Of the participants in this study, half (50%) indicated they currently incorporate precision agriculture technology concepts into their curriculum and classrooms. The courses in which teachers include lessons or units related to precision agriculture most often include “Introduction to Agriculture”, “Agribusiness”, “Ag Mechanics” and “Horticulture”. When asked what resources are used in their curriculum, teachers indicated that Self-Created Curriculum, Online Resources and Hands-On Technology were noted as the most common.

The personal characteristics which described the teachers who participated in this study noted details such as location, age, gender, student enrollment, education level, years teaching, and most common agricultural product in their area. This data provides in-depth information about the participants and how their decision to incorporate precision agriculture may be affected. The teachers in this study were almost evenly divided between Alabama and Illinois, with 50.7% and 49.3% from each state respectively. There were more male participants than female participants, and all participants were under the age of 65. The highest degree earned by the participants was indicated as a Specialist degree, but more teachers held Bachelor's and Master's degrees. The most common type of agriculture in the areas surrounding the participants in this study was identified as "Row Crops", followed closely by "Livestock/Animal Production".

A chi-square test of goodness of fit was performed to determine what relationships, if any, exist between the personal characteristics of teachers and their decision to incorporate precision agriculture concepts into their curriculum. The results from the chi-square test revealed no significant relationships exist between personal characteristics and the decision to incorporate precision agriculture.

The teachers in this study indicated a need for teacher education or professional development through a difference in their mean perceived importance of teaching precision agriculture and their mean self-perceived competence in teaching precision agriculture. This need is reiterated in the results from a theme analysis performed by researchers with the intent of defining barriers to the incorporation of precision agriculture into secondary agriculture coursework. The most common barriers to incorporation were identified as funding, curriculum, equipment, experience, and professional development.

Participants identified the most important topics in precision agriculture as GPS, Soil Sampling/Land Management, and Genetic Modification. The perceived future relevance of precision agriculture in classroom technologies, coursework/content, the agriculture industry and the agriculture job market were predominantly identified as either "somewhat" or "extremely relevant" by teachers.

Teacher participants provided individual definitions of precision agriculture, which were evaluated through a theme analysis. The following definition was produced to represent their perceptions. *"Precision agriculture is the use of agricultural technologies to make precise, data-based management decisions that increase efficiency and productivity in agriculture."*

Chapter V

Conclusions, Recommendations, and Implications

Summary

Purpose

The purpose of this study is to identify the curriculum involving precision agriculture technology that is currently taught, and gain insight into secondary agriculture education teachers' decisions of why they choose to integrate precision agriculture topics in agricultural curriculum. By understanding what is currently being taught by secondary agriculture education teachers, researchers may then be able to better provide opportunities for growth through professional development opportunities, industry network connections and educational workshops to encourage the incorporation of precision agriculture technology into curriculum. This incorporation must occur in order to keep secondary agriculture education relevant and in tune with industry trends that ultimately affect the careers of agriculture education students.

Objectives of the Study

The research questions to be addressed in this study are:

1. Describe the courses and curriculum currently being used to teach precision agriculture concepts;
2. Describe participants by their personal characteristics and their incorporation of precision agriculture concepts in their classrooms;
3. Describe the relationships between participant personal characteristics and their incorporation of precision agriculture concepts in their classrooms;

4. Describe participants by importance and competence with respect to teaching precision agriculture;
5. Describe the barriers teachers identify that prevent them from teaching precision agriculture;
6. Describe the most important topics in precision agriculture and the relevance of precision agriculture in the areas of education and agriculture; and
7. Define the term precision agriculture.

Study Design and Procedure. The survey instrument was developed by the researcher and was used to identify whether or not teachers chose to incorporate precision agriculture technology concepts into their curriculum and to investigate details as to how it is currently integrated or why teachers choose not to integrate precision agriculture concepts. The survey instrument also gathered teacher perceptions on precision agriculture itself, the most important topics within precision agriculture and the perceived future relevance. Data was collected during the 2017-2018 academic year from secondary agriculture teachers in Alabama and Illinois.

Population. Subject population consisted of certified secondary agriculture educators who are members of the National Association for Agricultural Educators. The membership rosters from Alabama (*N*=302) and Illinois (*N*=391) will serve as the populations for this study. Cochran's Theorem (1977) was utilized for the selection of possible participants to ensure an equal sample distribution and account for sampling bias in the participant sample. Oversampling techniques will ensure a statistically significant instrument return rate for the replacement of non-respondents.

Instrumentation. An exhaustive review of research revealed no current instrument which would appropriately address the research questions developed for this study. Therefore, the instrument was developed using existing literature in curriculum and development, technology use in classrooms, agricultural education content areas, and pilot study data representative of the population being investigated. The researcher designed the instrument specifically to collect data relevant to each individual teacher that would allow for the analysis and comparison of data between teachers who incorporate precision agriculture concepts into their coursework and those who do not.

A pilot test of the initial survey instrument was conducted with eight individuals who were selected to participate. These eight individuals were representative of the population, but were not included in the sample of the population utilized for the study. The individuals selected to provide feedback in the pilot test were selected by the researcher based on their knowledge of research and their likeliness to provide honest, applicable input. On August 30th, 2017, a link to the survey instrument was sent via email to five secondary high school agriculture teachers in Illinois and three teachers in Alabama. These teachers were asked to review the instrument and provide input on the potential ambiguity of statements, sentence structure and other changes that may be necessary. Results from the pilot test indicated a few necessary changes to the instrument, which were promptly made by the researcher and approved by the committee chair prior to survey distribution.

Data Collection and Analysis. The survey instrument was distributed to participants by the researcher utilizing Qualtrics, a research software program supported by Auburn University. Responses were recorded by Qualtrics and were assigned anonymous identifiers within the Qualtrics software to protect the privacy of participants. At the conclusion of data collection, data was downloaded to Microsoft Excel as a .csv file, then uploaded to SPSS for further analysis. Descriptive statistical analysis was used to identify demographic information as well as participant perceptions of most important topics in precision agriculture, and future relevance of precision agriculture. Inferential statistical analysis was used in the form of a Chi Square test for independence to identify relationships and correlations between subjects.

Major Findings

The major findings noted here were identified by the researcher as the most important results from this study. Fifty percent of the teachers who participated in this study indicated their integration of precision agriculture into their current curricula. Of those teachers who indicated their inclusion of precision agriculture concepts, the courses in which they most commonly include such topics were Introduction to Agriculture, Agribusiness, Ag Mechanics and Horticulture. Of the teachers who indicated they do not currently incorporate precision agriculture into their curricula, barriers to integration were identified as funding, equipment, curriculum, experience and professional development.

The participants in this study indicated their perceived most important topics in precision agriculture as GPS, Soil Sampling/Land Management, and Genetic Modification. Teachers also described the resources they use as their curricula, resulting in the most common resources being Self-created curriculum, Online resources and Hands-on learning. When asked about their perception of the future relevance of precision agriculture in their classrooms and in their coursework, participants indicated "extremely relevant", "somewhat relevant" or "no change in relevance from today". In the same question, with regards to the agriculture industry and in the agriculture job market, participants indicated precision agriculture being "extremely relevant" or "somewhat relevant" in 5-10 years. A *chi square* test of goodness of fit was performed to identify any relationships that may exist between participants' personal characteristics and their decisions to incorporate precision agriculture, but no significant relationships were found.

Conclusions

The conclusions of this study are not to be generalized beyond the parameters and participants of this study. The first research objective addresses the purpose of this study and describes the courses and curriculum currently being used to teach precision agriculture concepts. Results from the study indicate the courses that most often include precision agriculture concepts are Introduction to Agriculture, Agribusiness, Ag Mechanics and Horticulture. The resources used in secondary agriculture curriculum were identified by participants and reported by the decision to incorporate precision agriculture concepts. The results indicated only slight differences in how teachers who do and do not integrate precision agriculture build their curriculum. The teachers who include precision agriculture in their curricula most often use Self-Created Curriculum (59%), Online Resources (52%), and Hands-On Technology (45%). Teachers who do not include precision agriculture in their curriculum most often use Online Resources (65%), Hands-On Technology (59%) and Self-Created Curriculum (59%). Slight differences only exist in their uses of Purchased or Packaged Curriculum, Textbooks, Simulators or Other resources. The courses and curriculum currently being used to teach precision agriculture are common throughout agriculture education.

The second research objective describes participants by their personal characteristics and their decision to include precision agriculture concepts in their classrooms. The descriptive data describes the agriculture teachers in this sample and indicates the age, gender, location, education, tenure, enrollment and common agriculture in their area. The majority of the participants teach in rural schools with 60 or more students enrolled in their program. Half (50%) of the teachers who participated in this study incorporate precision agriculture concepts into their curricula, while 50% choose not to incorporate precision agriculture.

Objective three drives investigative research to describe the relationships between participant personal characteristics and their incorporation of precision agriculture concepts in their classrooms. A chi-square goodness of fit test was used by the researcher to identify any relationships between the personal characteristics of participants and their decision to incorporate precision agriculture concepts into their curricula. The chi-square test revealed no significant relationships between personal characteristics and the decision to integrate precision agriculture. This result leads the researcher to conclude that factors other than personal characteristics drive the decision to incorporate precision agriculture concepts.

The fourth research objective describes participants by their perceived importance and competence using the Borich (1980) model for assessing areas of need. In this case, teachers indicated their perception of precision agriculture's importance as higher than their competence in teaching precision agriculture. This difference in means indicates the need for teacher education, knowledge or professional development. Teachers view precision agriculture concepts as important topics to include in agriculture education, but do not feel adequately prepared to teach those topics.

Research objective five gathers the opinions of teachers who do not incorporate precision agriculture in their curricula through descriptions of the barriers that prevent them from doing so. A thematic analysis revealed five major categories that were repeatedly identified by teachers; funding, equipment, curriculum, experience and professional development. Teachers associate precision agriculture with high costs, equipment they do not have and curriculum that is different from what they currently teach. They also perceive themselves as lacking in experience with precision agriculture technologies and the professional training to accompany teaching it.

The sixth research objective addressed by this study evaluates teacher perceptions of the most important topics in precision agriculture as well as their perception of future relevance of precision agriculture across education and agriculture. The participating teachers in the sample chose the same topics as most important regardless of their decision to incorporate precision agriculture into their curricula. GPS, Soil Sampling/Land Management and Genetic Modification were identified as the most important topics in precision agriculture. In the second half of the objective, teachers were asked to indicate the relevance of precision agriculture 5-10 years in the future across four areas, two within education and two within agriculture. In the areas related to education (in your classroom, in your coursework/content), over half of the participating teachers indicated their perception of precision agriculture as “extremely relevant”. The remaining teachers indicated precision agriculture being either “somewhat relevant” in the future or “no change in relevance from today. In the areas related to agriculture (in the agriculture industry and in the agriculture job market), 75% of teachers indicated precision agriculture being “extremely relevant”, while the remaining 25% indicated precision agriculture being “somewhat relevant” 5-10 years in the future. The results from this objective are similar to those of objective four, as teachers recognize the importance and relevance of precision agriculture both in agriculture education and the agriculture industry itself.

The final research objective develops a definition of the term precision agriculture based on a thematic analysis of individual definitions provided by participants of the study. The thematic analysis found similar words and phrases across the responses initially provided, and formed a definition that was representative of those responses. *“Precision agriculture is the use* *of agricultural technologies to make precise, data-based management decisions that increase efficiency and productivity in agriculture."*

Recommendations

It is recommended that further research focusing on precision agriculture in agriculture education be conducted. As the agriculture industry grows and advances, so should agriculture education and research efforts. First, this study compiled a definition of precision agriculture as perceived by secondary agriculture instructors. Future studies should test this definition with secondary agriculture instructors outside the sample of this study. Specifically, an investigation of grant funding should be conducted. Opportunities for research related to precision agriculture in the classroom that would provide teachers with the funding and equipment necessary to teach precision agriculture should be identified and pursued. Also, to identify possible content areas or educational concepts that would better prepare students to enter careers in precision agriculture, future studies should be conducted involving individuals who currently hold careers in precision agriculture. By comparing the education patterns of those who currently hold careers in precision agriculture, preparatory education could become more specific and therefore more beneficial to those wishing to enter a career in precision agriculture.

As indicated by the teachers who participated in this study, there is a need for professional development and teacher education focusing on precision agriculture. Future studies should identify specific areas within precision agriculture that would be most beneficial to teachers and, in turn, their students. A compilation of resources for teachers to use in building curriculum is needed. Reliable information that is accurate and representative of what occurs in the agriculture industry should be gathered and presented to teachers for use in their classrooms and should be updated annually to best reflect the technologies used in the agriculture industry.

Similarly, partnerships between agriculture education and the companies that produce precision agriculture technologies should be formed so that teachers are equipped with the tools needed to educate their students, who are future agriculturalists, on the capabilities of precision agriculture. These industry partners are imperative to keeping secondary agriculture education relevant and sparking the interest of students to work in the agriculture industry.

This study found that half of the teachers who participated chose to incorporate precision agriculture concepts into their curriculum. Future studies should expand to include a larger sample of teachers and compare those results to the rate of precision agriculture adoption by farmers in their geographic areas.

Implications

Precision agriculture is a progressive and emerging topic in agriculture that is facing farmers with the decision to either move with the flow of technology or get left behind. Many people within agriculture, let alone outside the field, do not have an understanding of precision agriculture or what it entails. This leads to confusion, misinformation and general misconceptions surrounding the topic of precision agriculture, which underlines the importance of familiarizing future agriculturalists with the precision-rich agricultural future they are to inherit. Precision agriculture can be seen from two points of view, the innovative technology development and the application of technology in real life. We, as agricultural educators, must do our part in educating agriculturalists on the best practices for applying this emerging technology to its respective goal. Secondary agriculture educators work with students who live in this agriculturally rich world every day, they are our connection to the future of agriculture. By incorporating into coursework the precision agriculture technologies that are already being used in agriculture today, students will be better prepared for the future agriculture industry.

Teaching students to care for the environment is becoming prevalent in secondary agricultural education curriculum and precision agriculture content would be the next evolutionary step. Environmental science and stewardship practices define a component of production agriculture education and the inclusion of concepts which provide data based and technological components reinforce environmental science curriculum. The implications of combining precision agriculture and environmental science will aid in the development of students STEM processes and the ability to implement STEM practices in a meaningful and productive manner.

Continuing education for practicing agricultural education teachers should contain concepts and instruction in precision agriculture. Professional development opportunities would allow teachers to become more comfortable with the content and in the development of stand-alone modules or incorporation of precision agriculture concepts within existing curriculum. Agricultural education teachers should be provided pre-service training through Colleges of Agriculture or preparatory work in Colleges of Education as familiarity with the content would reduce anxiety and doubt for younger teachers and give direction to veteran teachers looking to update their course materials.

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APPENDIX A

Pilot: Assessing Teacher Practices Related to Precision Agriculture in Secondary Agriculture Education

Survey Flow

Block: Demographics (1 Question)
Standard: Teaching Practices (12 Questions)
Standard: Wrap-Up Questions: Looking Forward (1 Question)

Page Break

Start of Block: Demographics

Please review each statement/question below to provide feedback for each item according to **sentence structure, appropriateness of statement/question, punctuation, clarity, or ambiguity.**

End of Block: Demographics

Start of Block: Teaching Practices

In your own words, define the term "Precision Agriculture".

____

____

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Please self-identify your competence in teaching precision agriculture to your students.

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Please identify, in your opinion, the importance of teaching precision agriculture to your students.

____

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____

Do you currently teach precision agriculture concepts in your courses or teach courses pertaining to precision agriculture technologies?

____

Please select the courses you teach which contain units or lessons pertaining to precision agriculture. Please Select All That Apply.

____

Which topics related to precision agriculture are *most commonly incorporated into your current curriculum?* Please Select All That Apply.

____

Which Precision Agriculture concept is the *most important in the Agriculture Industry* in your opinion? Please Select All That Apply.

____

Which resources do you currently use to teach precision agriculture? Please Select All That Apply.

____

What, if any, barriers exist for incorporating precision agriculture technologies in your current coursework?

____

____

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____

Which resources do you most often currently use in your classroom? Please Select All That Apply.

____

What is the most important reason you have for not teaching or incorporating Precision Agriculture concepts in your classroom?

____

What Precision Agriculture concept is the most important in the Agriculture Industry in your opinion? Please Select All That Apply.

____

End of Block: Teaching Practices

Start of Block: Wrap-Up Questions: Looking Forward

How relevant do you predict Precision Agriculture topics to be in 5-10 years?

____

End of Block: Wrap-Up Questions: Looking Forward

APPENDIX B

Dear Agriscience Teacher,

My name is Abby Heidenreich, and I am a graduate student in Agriscience Education in the Department of Curriculum and Teaching at Auburn University. I would like to invite you to participate in my research study titled "Assessing Teacher Practices Related to Precision Agriculture in Secondary Agriculture Education".

Participants will be asked to answer teaching methods based questions using Qualtrics Software for Surveys. Your total time commitment to complete the survey is less than 10 minutes.

The purpose of this descriptive research study is to identify current methods of instruction and content taught related to precision agriculture. To accomplish this purpose, the following research objectives will be used to guide this study:

1. Establish a common definition of the term "precision agriculture".
2. Identify current courses or lessons that pertain to precision agriculture and identify the most
common topics within precision agriculture are incorporated in curriculum.
3. Identify resources that are currently used to teach precision agriculture concepts.

Follow this link to the Survey:

Take the Survey

Or copy and paste the URL below into your internet browser:

https://auburn.qualtrics.com/jfe/preview/SV_e8VkcAz0vCobZit?Q_CHL=preview

Follow the link to opt out of future emails: Click here to unsubscribe

Thank you for your consideration,

Abigail E. Heidenreich
Graduate Assistant

Agriscience Education
Auburn University
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APPENDIX C

Assessing Teacher Practices Related to Precision Agriculture in Secondary Agriculture Education

Survey Flow

Standard: Block 3 (1 Question)
Standard: Teaching Practices (11 Questions)
Standard: Wrap-Up Questions: Looking Forward (2 Questions)
Block: Demographics (9 Questions)

Page Break

Start of Block: Block 3

Assessing Teacher Practices Related to Precision Agriculture in Secondary Agriculture Education

We are conducting this study and invite you to participate. This study is best taken on a desktop/laptop/tablet; given the type of questioning used participation on a smartphone may be problematic. You and other Agriscience teachers in Illinois and Alabama are the only source of data for this study. We ask you to review the informed consent information sheet (details) and complete the accompanying questionnaire; your participation will take about 10 minutes. Things you should now about your participation: Your participation is voluntary. You may stop participating at any time. You will not be compensated for participation. Participation involves minimal risk (no more than occurs during daily life). Information about participants will be kept confidential and no individual responses will be reported.
Please do not hesitate to contact Abby Heidenreich or Dr. Chris Clemons if you have any questions about this research project. For further information, click the "Information Letter" link below.
Information letter
This survey should take approximately 10 minutes to complete.

Thank you!

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○ I **AGREE** to participate (I have read the informed consent information sheet and agree to participation) (1)

○ I **DO NOT** wish to participate (2)

End of Block: Block 3

Start of Block: Teaching Practices

Identify your competence of the following statement.

	5 - Competent (1)	4 - Slightly competent (2)	3 - Neither competent nor incompetent (3)	2 - Slightly incompetent (4)	1 - Incompetent (5)
In teaching Precision Agriculture concepts, I feel I am: (1)	○	○	○	○	○

Identify the importance of the following statement.

	5 - Important (1)	4 - Slightly Important (2)	3 - Neither Important nor Unimportant (3)	2 - Slightly Unimportant (4)	1 - Unimportant (5)
I feel that teaching Precision Agriculture concepts are: (1)	○	○	○	○	○

Do you currently teach precision agriculture concepts in your agriculture courses?

- Yes (1)
- No (2)

Skip To: Q21 If Do you currently teach precision agriculture concepts in your agriculture courses? = Yes

Skip To: Q24 If Do you currently teach precision agriculture concepts in your agriculture courses? = No

Select the courses you teach which contain units or lessons pertaining to precision agriculture. Please Select All That Apply.

- Introduction to Ag (1)
- Horticulture (2)
- Animal Science (3)
- Ag Mechanics (4)
- Ag Construction (5)
- Agribusiness (6)
- Forestry (7)
- Aquaculture (8)
- Agriculture Leadership (9)
- Cooperative Class (10)
- Other (11) ____

Which topics related to precision agriculture are *most commonly incorporated into your current curriculum?* Please Select All That Apply.

- ▢ GPS (1)
- ▢ Yield Mapping (2)
- ▢ Soil Sampling/Land Management Practices (3)
- ▢ Production Monitoring (4)
- ▢ Satellite Imaging (5)
- ▢ Variable Rate Technology (6)
- ▢ Unmanned Aerial Systems (UAS/UAV) (7)
- ▢ Other (Please Specify) (8) ____

In your opinion, which Precision Agriculture concept is the *most important* in Agriculture today?

- ◯ GPS Technology (1)
- ◯ Variable Rate Technology (2)
- ◯ Satellite Imaging (3)
- ◯ Land Management Practices (4)
- ◯ Yield Monitoring (5)
- ◯ Automatic Production Systems (6)
- ◯ Unmanned Aerial Systems (UAS/UAV) (7)
- ◯ Genetic Modification (8)
- ◯ Chemical Technology (9)
- ◯ Other (Please Specify) (10) ____________________

Which resources (curriculum, training, etc.) do you currently use to teach precision agriculture? Please Select All That Apply.

- ▢ Purchased/Packaged Curriculum (1)
- ▢ Self-Created Curriculum (2)
- ▢ Textbook (3)
- ▢ Online Resources (4)
- ▢ Simulators (5)
- ▢ Hands-On Technology (6)
- ▢ Other (Please Specify) (7) ____

Skip To: End of Block If Selected Choices >= 0

What barriers do you believe exist to incorporating precision agriculture technologies in your current coursework?

____

____

____

____

____

Which resources (curriculum, training, etc.) do you most often currently use in your classroom? Please Select All That Apply.

- ▢ Purchased/Packaged Curriculum (1)
- ▢ Self-Created Curriculum (2)
- ▢ Textbook (3)
- ▢ Online Resources (4)
- ▢ Simulators (5)
- ▢ Hands-On Technology (6)
- ▢ Other (Please Specify) (7) ____

What is the biggest reason for not teaching or incorporating Precision Agriculture concepts in your classroom? Drag and drop the statements below in the order of which you agree.
_______ Lack of Funding (1)
_______ Lack of Equipment (2)
_______ Doesn't align with current curriculum (3)
_______ I don't feel comfortable teaching the concepts (4)
_______ It's pointless to try and keep up with the changing technology (5)
_______ All of the Above (6)

In your opinion, which Precision Agriculture concept is the *most important* in Agriculture today?

- ◯ GPS Technology (1)
- ◯ Variable Rate Technology (2)
- ◯ Satellite Imaging (3)
- ◯ Land Management Practices (4)
- ◯ Yield Monitoring (5)
- ◯ Automatic Production Systems (6)
- ◯ Unmanned Aerial Systems (UAS/UAV) (7)
- ◯ Genetic Modification (8)
- ◯ Chemical Technology (9)
- ◯ Other (Please Specify) (10) ____

End of Block: Teaching Practices

Start of Block: Wrap-Up Questions: Looking Forward

Reading the statements below, how relevant do you predict Precision Agriculture topics to be in 5-10 years?

	5 - Extremely Relevant (1)	4 - Somewhat Relevant (2)	3 - No Change In Relevance From Today (3)	2 - Somewhat Irrelevant (4)	1 - Extremely Irrelevant (5)
In Your Classroom Technologies (1)	o	o	o	o	o
In Your Coursework/Content (2)	o	o	o	o	o
In the Agriculture Industry (3)	o	o	o	o	o
In the Agriculture Job Market (4)	o	o	o	o	o

How would you define the term "Precision Agriculture"?

____

____

____

____

____

End of Block: Wrap-Up Questions: Looking Forward

Start of Block: Demographics

In what state do you currently teach?

- ◯ Alabama (1)
- ◯ Illinois (2)

How many students are currently enrolled in your agriculture program?

- ◯ 1-20 (1)
- ◯ 20-40 (2)
- ◯ 40-60 (3)
- ◯ 60+ (4)

How many of your enrolled students are FFA members?

- ◯ 1-20 (1)
- ◯ 20-40 (2)
- ◯ 40-60 (3)
- ◯ 60+ (4)

Which description best identifies the location of your school?

- ○ Rural (1)
- ○ Suburban (2)
- ○ Urban (3)

What is the most common type of agriculture in your area? Please Select All That Apply.

- ☐ Row Crop (1)
- ☐ Livestock/Animal Production (2)
- ☐ Fruit Production (3)
- ☐ Dairy (4)
- ☐ Other (Please Specify) (5) ____

Not including this year (2017-2018), how many years have you been teaching agriculture?

- ○ 0-5 Years (1)
- ○ 6-10 Years (2)
- ○ 11-20 Years (3)
- ○ 21-30 Years (4)
- ○ 30+ Years (5)

What is the highest degree you earned?

- High School Diploma or Equivalent (1)
- Associate's Degree (2)
- Bachelor's Degree (3)
- Master's Degree (4)
- Specialist Degree (6)
- Doctorate (5)

What is your age?

- 18-24 (1)
- 25-34 (2)
- 35-44 (3)
- 45-54 (4)
- 55-64 (5)
- 65-74 (6)
- 75 years or older (7)

What is your gender?

- ○ Male (1)
- ○ Female (2)
- ○ Transgender (3)
- ○ Other (4)
- ○ Prefer not to say (5)

End of Block: Demographics
