# A COMPARATIVE ANALYSIS OF AGRICULTURE AND SCIENCE TEACHERS' PERCIEVED APPROACH AND EFFICACY TEACHING PROBLEM-SOLVING

by

**Bryanna Nelson**

**A Thesis**

*Submitted to the Faculty of Purdue University*

*In Partial Fulfillment of the Requirements for the degree of*

**Master of Science**

Department of Agricultural Sciences Education and Communication

West Lafayette, Indiana

May 2020

# THE PURDUE UNIVERSITY GRADUATE SCHOOL
# STATEMENT OF COMMITTEE APPROVAL


**Dr. Hui-Hui Wang, Chair**

Department Agricultural Sciences Education and Communication

**Dr. Neil Knobloch**

Department of Agricultural Sciences Education and Communication

**Dr. Sarah LaRose**

Department of Agricultural Sciences Education and Communication


**Approved by:**

Dr.  Mark Russell

*This thesis is dedicated to my parents and sisters.*

*For their endless love, support, encouragement and laughter.*

# ACKNOWLEDGMENTS

*To my family*—Dad, Mom, Amanda and Payton, thank you for always loving and supporting me no matter what the endeavor. Thank you, Mom, for always being a phone call away, and for giving me the same recipe time and time again, never complaining that I failed to write it down. Dad, thank you for being just a phone call away, to listen to me vent and complain about the stress of grad school. Amanda and Payton, thank you for our daily snapchats, texts, and phone calls. You both provided me so much joy throughout this journey and encouraged me every step of the way. I can't thank you all enough for all the laughter and good times you have given me despite being hundreds of miles away.

*To Anthony*—Thank you for being there every step of the way. Your support and encouragement every time I felt like giving up or lost hope in this journey is something, I can never thank you enough for. Thank you for every late-night meal, nights on the couch playing video games, and endless amounts of laughter. Also, thanks for moving to Indiana with me, that was pretty cool of you.

*To my advisor, Dr. Wang*—We did it! Thank you, Dr. Wang for helping every step of the way, for guiding me through academia, research, and when I was stuck and didn't know where to go. Thank you for always being there for me, correcting every document, answering every question, and replying to every email. I appreciate every meeting starting and ending with a laugher and encouraging words. Thank you for always being an advocate for me, supporting me, and encouraging me, you were the best advisor I could have ever hoped for.

*To my thesis committee*—Dr. Knobloch and Dr. LaRose, thank you for supporting me through your technical knowledge and professional expertise. Dr. Knobloch, thank you for being a second advisor to me, helping me understand statistics, and always encouraging me to go deeper and do more. Dr. LaRose, thank you for your insight and knowledge in the world of agricultural education and research. I could not have completed this task without you both by my side.

*To my ASEC Colleagues and Friends*—Thank you all for showing me the ropes, joining me for social outings, many lunches and conversations, and a little commiserating too. I could not imagine completing graduate school without you.

*To the ASEC department*—Thank you all for helping me in whatever way you could. Thank you, Richard and Craig, for always helping with any problem I had and providing me with laughter. Dr. Esters and Dr. Brady, thank you for being so welcoming and kind during our seminar class, you made graduate school a little less daunting and provided me with irreplaceable knowledge. Dr. Tucker, thank you for helping me with my first journal article and answering every question I had. And lastly, thank you to everyone in the department, I only felt encouragement and support from each and everyone one of you!

*To Dr. Talbert*—without your help, this thesis may not have been completed. Thank you for giving me your and your students time to pilot test my instrument. The results of the pilot test provided the necessary feedback and insight to improve my instrument and study. Additionally, thank you for helping distribute my survey to agriculture teachers in Indiana and answering questions related to the Listserv.

*To my Minnesota Besties*—Hannah, Annie, and Lizzie, your support and encouragement means the world to me! Thank you for always checking-in on me and being there when I needed you most.

*To Animal Crossing*—Thank you for being the best stress reliever after long days of writing, reading, and analyzing data. You provided me something to look forward to every day, even if I knew it was going to be a difficult one.

Finally, thank you to all of my former professors from UWRF and Purdue, former teachers, colleagues, friends, supervisors, coworkers, mentors, and many, many more. Thank you for encouraging me and supporting me even before this journey. Many of you helped get me to where I am today, and for that I cannot express enough gratitude.

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# ABSTRACT

Author: Nelson, Bryanna M.S
Institution: Purdue University
Degree Received: May 2020
Title: A Comparative Analysis of Agriculture and Science Teachers' Perceived Approach and Efficacy Teaching Problem Solving
Committee Chair: Dr. Hui-Hui Wang

The need for STEM employees is on the rise in direct relation with the changing needs of our globe (Jang, 2015). There are gaps to be filled not only in the workforce and industry, but also by academia and government (Jang, 2015). K-12 STEM education has the ability to address 21st century problems, in particular, the need for more highly skilled workers in STEM fields by focusing on developing students' 21st century skills. A critical skill for students to develop to be able to properly collaborate on teams and engage in the STEM workforce is problem solving. Problem solving is thought of as being the most important cognitive goal of education in every educational context: formal, informal, public schools, universities, and everything in between (Jonassen, 2010). In order to properly assess students, and know where improvements could be made, it is vital that we examine teachers first. By exploring how teachers approach problem-solving, and how self-efficacious they feel teaching problem-solving, then we can determine how to better assist both teachers and students. The current study sought to address this gap in the literature through surveying three states agriculture and science teachers using two established instruments. The survey was distributed online via Qualtrics and was available to participants for three weeks during the month of January 2020. The survey is divided into three major sections with the first two sections being the instruments used: (1) Problem Solving

Inventory, (2) Teaching Science as Inquiry, and (3) Demographics. Demographics was placed at the end of the survey following recommendations from Dillman et al. (2014).

The final response rate for the survey was 9.04% for agriculture teachers and 13.4% for science teachers, a total of 22.44% (n = 504). After data cleaning there is a total of 4.3% of useable responses from agriculture and 5.58% for science resulting in a usable response rate of 9.88% (n = 205). A little more than half of the participants were female (59%) with the remainder being male (39.5%) and a small percentage (1.5%) elected not to respond or selected “prefer not to say”. The largest population that responded to the survey were between the ages of 44 and 54 (43.1%) and teaching for 21-25 years (19%). The survey found that teachers thought of themselves as being confident problem-solvers but used a more avoidance-style. Teachers also felt they had less control or had more negative feelings in regard to problem-solving. Overall, teachers from both agriculture and science viewed themselves as being moderate to high problem-solvers in general. The instrument was not intended to measure problem-solving relating to the classroom. The second instrument, the Teaching Science as Inquiry, measured how efficacious they felt teaching problem-solving. Teachers from both science and agriculture perceived themselves as being very self-efficacious and had high expectancy outcomes. ANOVA tests were conducted between the two groups to determine if there were differences in their responses and no statistically significant differences were found. A correlation was conducted in order to determine which variables from the two instruments held relationships. The correlation suggests that the two instruments have several strong relationships between the variables like personal self-efficacy and expectation outcomes. research should focus on refining the instruments to reduce the number of questions and survey more individuals to capture more generalizable results.

# CHAPTER 1. INTRODUCTION

## 1.1 Introduction

The need for STEM employees is on the rise in direct relation with the changing needs of the global workforce (Jang, 2015). There are gaps to be filled not only in the workforce and industry, but also by academia and government (Jang, 2015). Science, technology, engineering and math (STEM)-related jobs grew three times the rate than non-STEM jobs between 2000 and 2010, and by 2018 it is projected that 2.4 million STEM jobs will go unfilled (Langdon et al., 2011). K-12 STEM education has the ability to address 21st century problems. Particularly, the need to focus on more highly skilled workers in STEM fields by developing students' 21st century skills.

For students to be competitive and fill the needs of a changing STEM job market, it is crucial that students develop 21st century skills. These skills are divided into 3 categories: *Learning and Innovation Skills, Digital Literacy Skills, and Career and Life Skills* (Trilling & Fadel, 2009). Problem-solving is a critical skill for students to develop to be able to properly collaborate on teams and engage in the STEM workforce. Problem-solving is thought of as being the most important cognitive goal of education in every educational context: formal, informal, public schools, universities, and everything in between (Jonassen, 2010). Student experiences and real-life settings are vital, and the way in which students are problem-solving, relates directly to said knowledge and experience. Similar to STEM, agriculture and natural resource employers also value skills like critical thinking and problem-solving skills (Easterly et al., 2017). Industry leaders ranked these skills highly and expect students to obtain following post-secondary education.

Historically, problem-solving has been an integral component to both agricultural and science education, though it has evolved over the years. In agricultural education, the problem-solving approach to teaching has often been thought of as the way to each agricultural education (Crunkilton & Krebs, 1982; Newcomb McCracken, & Warmbrod, 1986; Phipps & Osborne, 1988), and shows a higher retention of knowledge in comparison to other hands-on techniques (Flowers & Osborne, 1987). Agriculture approaches design and delivery of curriculum from a "hands-on, minds-on" approach (Parr & Edwards, 2004), which emphasizes the popularity of utilizing problem-solving as a teaching method. The problem-solving method is so integral to agricultural education, that the methods are passed down generationally from older members in the profession (Rice & Kitchel, 2015).

The problem-solving approach to teaching, also has played a central role (Taconis et al., 2000) in science education. Problem-solving in science historically had students working on a large number of problems individually (Taconis et al., 2000), rather than in groups or teams. Typically, instruction and feedback were less focused on the knowledge and cognitive strategies in order to solve the problems, but rather students' ability to follow a determined sequence of problem-solving steps (Taconis, 1995). More recently, problem-solving instruction and approaches are inspired by theories on the role of schemata in domain knowledge (Gick & Holyoak, 1983) or by theories on mental models (Chi & Bassok, 1989). As of recent, and as early as 1998, there is an emphasis in using computers and modern technology as a method for teaching problem-solving (Taconis, et al., 2000). This adds value for the need to explore science teachers' knowledge about problem-solving, and beliefs towards teaching problem-solving, as teaching methods will need to evolve with the advancement of technology.

### 1.1.1 Comparison of Agriculture and Science Educators

Agriculture and science education are often thought of as being closely related fields. Shepardson stated: “Agriculture is a meeting-ground of the sciences. Physics and chemistry lie at its base. To these elements’ biology adds its conception of organisms. Mathematics is their common instrument” (1929, p. 69). Due to their close nature and emphasis in using problem-solving methods, the two subjects provide natural groups for comparison. Despite their similarities, teaching styles and beliefs are often different, which can be attributed to training, pedagogical content knowledge (PCK), experiences, and even teachers’ personality (Decker & Rimm-Kaufman, 2008; Lumpe et al, 2012). It should be noted that agriculture teachers are defined as those that teach agriculture courses in a middle or high school setting. In certain areas of the country they may be referred to as Agriscience educators, vocational educators, and other variations. Science teachers are those that teach typical middle and high school science courses like biology, chemistry, physics, and earth and space science primarily.

Agricultural education tends to base their teaching practices on sources of knowledge that surround experiences such as teachings from their own high school teachers or local 4-H leaders (Rice & Kitchel, 2105). Pre-service teacher training has largely emphasized the history of agricultural education and the three-component model, which involves classroom and lab instruction, intracurricular instruction, and experiential learning such as supervised agricultural experiences (SAE) (Croom, 2008). As agricultural educators are expected to be knowledgeable in many areas (e.g., animal science, plant science, agricultural economics, and so on), as opposed to science teachers who specialize in one area such as biology or chemistry, training tends to be more focused on applying the knowledge in a practical way, such as increasing production of animals. Instruction is often focused on realistic scenarios and applications such as calculating feed rations or determining a best management practice. Core classes often focus on the development of practice by creating lesson plans, teaching them to peers, and reflecting. Courses focus on developing future teachers and providing them a solid foundation. Common courses include a methods course, foundations and philosophies, and program planning. Topics most often discussed in these courses include micro-lessons, SAE, philosophical issues, and problem-solving (McLean & Camp, 2002). Problem-solving is not only a skill, but a discipline specific method to agricultural education often referred to as the Problem-Solving Approach to Teaching. This method is most often taught in a pre-service methods course followed by general teaching methods, individual teaching techniques, questioning and discussion (Ball & Knobloch, 2005). Lessons from these courses may be to focus on developing "bell-ringers" or connecting to standards, so topics might vary from aquaculture, to forestry, or even mechanical. The common thread is they are all related to agriculture, but not necessarily within the same discipline as opposed to all biology related topics in science education.

Both science and agriculture pre-service training involves learning methods such as the problem-solving approach to teaching, inquiry-based teaching, discovery learning, and many more. Primarily, science education emphasizes the use of inquiry-based learning (NRC, 2000) over problem-based learning, the preferred method for agriculture. Inquiry-based learning in science education often involves proposing explanations for phenomenon using evidence, critical thinking skills, and considering alternative explanations (NRC, 2000). As inquiry often is utilized for explaining phenomenon like "how the seasons change" or "how does the moon effect ocean currents" it is not as real world oriented as problem-based learning. Student often enter the classroom with 'theories' about how to explain certain phenomenon's that teachers will need to address (Aguirre et al., 1990). Pre-service teaching programs often emphasize how to address these private theories. As a teachers' attitudes and beliefs help shape instructional practices, the types of instruction may vary depending on their beliefs. For example, teachers with negative views about science will be less likely to utilize teaching methods like inquiry-based learning (Ucar & Sanalan, 2011). Science teacher beliefs are often shaped by their undergraduate science and science method courses (Skamp & Mueller, 2001). As a result, methods courses are designed to positively influence beliefs so teachers will be excited about teaching science. Similar to agriculture teachers, science teachers also enter pre-service education shaped by the knowledge of the techniques and methods their secondary school teachers used.

In the latest science education reform movement, science education has shifted from explaining natural phenomenon to solving real-world problems by integrating engineering design into K-12 science education. The Next Generation Science Standards (NGSS, 2013), has outlined eight science and engineering practices to reflect how scientists and engineers engage in investigations and build models. Out of eight science and engineering practices, only two practices (asking questions and defining problems, and constructing explanations and design solutions) are called out to distinguish the practices of scientific inquiry and engineering design (NGSS, 2013). This indicates that inquiry (science) and problem-solving (engineering design) are related practices in the NGSS framework.

### 1.1.2 Importance and Relevance of Problem Solving

Problem-solving is not only an integral part of education, but everyday life. Problem-solving is a valuable skill in the workforce, education, relationships, the list goes on (Woods, 2000). Since problem-solving is essential to everyday life, it is essential that students develop these skills to show independence, and keep up in our ever changing, fast paced world. As a result, many fields are heavily reliant on problem solving methods and techniques to create uniformity. For example, to diagnose if a person has stroke (identify a problem), we rely on a standard procedure, which is if the person has face drooping, unable to lift one or both arms, and slurred speech. If the person has all the symptoms, it is the time to call an ambulance. This standard procedure has an acronym called "FAST", which stands for "face", "arms", "slurred speech" and "time", and is used to identify cases of stroke in the medical field. Woods (2000), identifies over 150 basic strategies to problem solving in a wide variety of fields. Most strategies have between two and seven steps, start with words that describe an awareness of a problem, and often employ an acronym for easy recall. As problem-solving is often an individualized process, being consistent and problem-solving in a uniform way is highly valued in areas like the medicine, the military, engineering, psychology, and even design or music.

### 1.1.3 Knowledge and Beliefs in Teaching Problem Solving

To perform a task, knowledge and beliefs come together to inform how to do tasks and in what way (Antonietti, Ignazi & Perego, 2000). When solving problems, there are discipline specific problems that require specific knowledge, and problems that are not discipline specific. Often the way in which a person solves each problem varies (Woods, 2000). Van Merrienboer (2013) suggested the knowledge a person holds regarding domain-specific questions, helps support their problem-solving abilities. He further asserted that solving problems in domains outside of the one's comfort zone is difficult (Van Merrienboer, 2013). Therefore, domain-specific knowledge, education and training that teachers received might play an important role in how they teach problem-solving to their students.

Beliefs come in to play when teaching problem-solving as beliefs inform instruction and practices. One aspect of beliefs is self-efficacy as they often serve as a cognitive filter that screens the teacher's experiences and shapes their thoughts and actions (Woolfolk Hoy et al., 2009). These thoughts and actions are a culmination from experiences in regard to students, teaching, and learning, and act as the driving force that develops their plans, moment-to-moment decisions, teaching strategies, assessment and more (Woolfolk Hoy et al., 2009). It is argued that self-efficacy for teaching is the strongest, and most important belief in education, as self-efficacy guides so many aspects about teaching and classroom life in general (Woolfolk Hoy et al., 2009). Self-efficacy is often tied to expectancy outcomes (Bandura, 1997), which will be heavily focused on. Teacher's beliefs may change and align with methods that are thought to be more successful than others and will drive their decisions regarding implementation (Gregoire, 2003).

**1.1.3.1 Statement of the Problem**

As problem-solving skills are necessary for 21st century learners, these skills need to be developed throughout one's schooling career. Agricultural education and science education both provide opportunities for students to engage in problem-solving activities. Although closely related subjects that are often integrated, differences are seen when it comes to instructional practices (Perry et al., 2014; Taconis et al., 2000) and epistemology (Gordon & Ball, 2017; Kirschner, 1992). There is a lack of empirical research when it comes to teachers perceived problem-solving approaches and problem solving efficacy, as well as their teaching efficacy towards problem-solving. Therefore, the researcher of this study was guided by the following questions: (1) How do agriculture teachers and science teachers perceive their problem-solving abilities, (2) how efficacious do teachers feel towards teaching problem-solving, and (3) are there differences between science and agriculture teachers in teaching problem solving? Answers to these three questions will inform the field by determining how teachers might be approaching problem-solving, their knowledge of problem-solving, and whether they feel efficacious, and their beliefs about how to teach problem-solving. As problem-solving is a major emphasis in the development of 21st century skills for students, knowing how teachers are approaching this concept will be important for future educators, students, policy makers, and employers.

## 1.2 Need for Study

The need for this study can be summarized by three main categories: field specific problem-solving abilities, teaching problem-solving in science and agriculture, and relationships between science teachers and agriculture teachers. Each of these needs are a result of a lack of empirical evidence, lack of related studies, or insufficient information related to the study.

Previous studies in agricultural education have explored cognitive styles, problem complexity, and the ability to problem solve, in terms of length of time to solve a problem (Blackburn & Robinson, 2016; Blackburn et al., 2014). The two studies were completed with both preservice teachers and later with SBAE students to determine if there was a relationship. With teachers, Blackburn (2014) found that there were no differences based on content knowledge and cognitive style. They defined cognitive style as being either adaptive or innovative based on the Kirton's Adaptation Innovation Inventory. In other words, there was no relationship between the content knowledge a person held and whether they were innovative or adaptive. They did, however, find there was a relationship with problem complexity and cognitive style. In the follow up study with students, Blackburn and Robinson (2016) found no relationship between cognitive style and problem complexity, but those that generated a correct hypothesis were most efficient at solving the problem.

Other studies have explored the effect of teaching approaches and the problem-solving ability of students with varying learning styles (Dyer & Osborne, 1996). Although these studies both highlighted the importance of using prior knowledge and problem-solving styles, Dyer and Osborne (1996) found that there were no differences in learning style approaches ability to solve problems. This might suggest that problem-solving is more oriented towards personality, or utilizing specific steps, or a mixture of both, but without further exploration it is open to interpretation. In science education, recent studies explore students' problem-solving capabilities (Nurdyansyah et al., 2017) and integrating new technology and computational methods related to STEM education (Herlina et al., 2017; Yadav et al., 2016). These studies helped develop reasoning as to why a teacher need to be both efficacious in their own problem-solving abilities and teaching problem-solving, so students can integrate these skills into their future lives and careers.

Often agriculture tries to incorporate science topics and concepts and has a dedicated curriculum for assisting teachers with this task. Science utilizes the Next Generation Science Standards (2013) which emphasizes contextualizing science. Agriculture is an area that science often uses to contextualize topics like photosynthesis or the carbon cycle. As farmers, horticulturalists, soil scientists and other professions related to the agricultural industry rely on this information, it creates applicable knowledge for students. Recent reforms in agricultural education such as the introduction of the Curriculum for Agricultural Science Education (2010), emphasized agriculture being contextualized as science. Both science and agriculture have recently been incorporating elements and concepts from the other discipline, so students get a real world view. This enhances teaching in both areas as it helps address the common question "why are we learning this?". As a result of these reforms, several studies have looked at how science teachers teach agriculture, and how agriculture teachers teach science. A study by Mueller et al. (2015) looked at agriculture teachers' perceptions of teaching biotechnology, a science content heavy topic. Teachers cited weaknesses in their units including too much content, it was too difficult, and it was not interesting. There is a desire to teach science in agriculture and agriculture in science, yet attitudes on how to integrate varies. Teachers agreed that preservice education courses are necessary in order to properly integrate (Thompson & Warnick, 2007). Exploring these two groups is relevant to recent reforms and a lack of studies supports further examination of between science and agriculture teachers.

## 1.3 Significance of the Study

The significance of this study can be summarized into three categories: workforce development, teacher professional development, and curriculum development. Workforce development is a vital component of agricultural education and influences STEM education. Twenty-first century skills can be developed by using problem-based learning with students. As these skills show independence, emphasis in the development of problem-solving skills will entice future employers. Enforcing the development of these skills will make students highly sought-after following graduation for employment, and potentially during high school (Farrugia & Sanger, 2017). Not only is problem-solving valued in agricultural education, but in science and STEM education as well (Garrett, 1987). Exploring beliefs towards teaching problem solving is vital for undergraduate education and teachers professional development. To ensure that future teachers are confident in teaching problem-solving as one of the critical 21st century skills, it is necessary to understand what current teachers are struggling with, as well as their current teaching practices. As a result, future studies, collaborations, and teacher professional development offerings can address areas where teachers need assistance. This could potentially lead to more personalized teacher professional development experiences to support teachers where it is most needed. As a result, new curriculum and other materials could potentially help students and teachers address areas of need when developing problem-solving skills.

## 1.4 Purpose of the Study and Research Questions

The purpose of this study was to explore and describe agricultural educators' and science educators' perceived problem-solving approaches as their knowledge to solve a problem, and their self-efficacy towards teaching problem-solving to students, and to identify how they relate to each other. This study was guided by three research questions with the goal of determining how science and agriculture teachers approach problem-solving, how they differ, and how their perceived self-efficacy towards teaching problem-solving. The three research questions were:

1. What approaches do agricultural teachers and science teachers have towards problem-solving?
2. What levels of self-efficacy do agricultural teachers and science teachers hold towards teaching problem-solving?
3. What relationships exist between problem-solving approaches (PSC, AAS and PC) and efficacy towards teaching problem-solving (PSE and EO) in agricultural teachers and science teachers?

    3a. What percent of variability in the sum of variables (i.e., PSC, AAS, PC, and PSE) are related when regressed towards teacher's expectancy outcomes?

    3b. Do the same relationships exist for agriculture teachers and science teachers?

## 1.5 Assumptions and Limitations

### 1.5.1 Assumptions.

For this study, it is assumed that the participants teach high school students (9-12th grade), in a public-school setting. Teachers from private, charter, or alternative high schools have been excluded for consistency when comparing groups. It is assumed that the teachers are licensed and currently teach science, in varying disciplines such as biology, chemistry, physics, etc., or agriculture, or both science and agriculture. It is also assumed that the participants will teach in the states in which the survey was sent (Ohio, Iowa or Indiana). It is assumed that responses to the survey will be valid as two valid instruments were used to create the distributed survey, and a pilot test was done to confirm validity and functionality.

### 1.5.2 Limitations.

The limitations to the study including instrumentation, attitudes of subjects, population, statistical conclusion validity, and survey fatigue. For instrumentation, there is an element of confirmation bias, in which participants answer questions based on what they think the researcher wants to hear. In this case, participants might respond that they are using many different methods for teaching problem-solving, or the instrument is not eliciting the answers sought after. Controlling for this limitation is difficult, but using two previously published, reliable surveys will hopefully reduce this. These items are threats to internal validity, as they are concerns to how the participants receive and respond to the questions based on their own perspectives. To control for this, the way in which the instrument is selected or created, needs to be valid and reliable, so pilot or test studies were conducted to ensure validity. The population could also be a limitation, as only three states were surveyed, creating a limited number of potential participants. If the survey was nationwide, the survey would be available to more potential participants, creating higher reliability. The study focusing on only three states also limited the study as it is not generalizable to the entire US, or even the Midwest. This limited the power of the study but does allow for further studies to be conducted using a similar methodology and survey. As the study does combine two independent surveys in addition to demographic questions, participants may experience survey fatigue. Duplicate or similar questions were reduced as much as possible to prevent participants answering more than necessary. Participants in agriculture may also experience survey fatigue as they are a smaller group in comparison to science education and may receive more surveys from other studies more often than those in science. As the survey is being distributed to two distinct fields a limitation is potentially agriculture teachers and science teachers interpreting problem-solving teaching based on their training and previous experiences. In order to control for this limitation, definition will be provided prior to questions regarding problem-solving teaching.

## 1.6 Operational Definitions

For the purpose of this study, the following items were defined:

**Agriculture Teachers:** Agriculture teachers are defined as those that currently teach School-Based agricultural education (SBAE). They may identify as vocational educators, Agriscience teachers, or other variations, but for this study, they will be identified as agriculture teachers. Teachers included in this study are members of a state-wide listserv for agricultural educators in Indiana, Iowa, and Ohio. Dual-certified teachers will be identified by their primary discipline.

**Science Teachers:** Science teacher is broadly defined for this study and includes those that teach biology, chemistry, physics, Earth and space science, environmental science, or technology/engineering. Teachers are defined by self-identification and by their listing on their school website. Dual-certified teachers will be identified as their primary discipline.

**Dual-Certified Teachers:** Dual-certified teachers is defined as those that teach both agriculture and science. Although science teachers may be certified in biology and chemistry, or other variations, they will not be identified as dual-certified.

**Self-Efficacy:** The following definitions define and operationalize self-efficacy in relation to teaching and self-perception. Merriam-Webster defines efficacy as simply the power to produce an effect, so operationalizing this is necessary.

**Perceived Self-Efficacy:** Bandura (1994) defines perceived self-efficacy as "people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives" (p. 1). Self-efficacy not only relates to how people perform, but how they are motivated and behave; this is often referred to as beliefs. Beliefs are often broken down into four major categories: cognitive, motivational, affective and selection process.

**Teaching Efficacy/Teaching Self-Efficacy:** In relation to self-efficacy, teachers have efficacy and beliefs towards teaching, often referred to as teaching efficacy. Poulou (2007) defines this as "teachers' confidence in their ability to perform the actions that lead to student learning" (p. 191). Poulou also found that teaching efficacy and self-perceptions were comprised of contributing factors such as teaching competency, personal characteristics, and motivation. Like perceived self-efficacy, there are many layers to one's belief system, especially in relation to teaching.

**Problem-based learning:** Problem-based learning has different definitions depending on the field of application. For science education "learning is fostered when students have the opportunity to formulate and achieve their own learning goals" (Dewey, 1910; Gijbels, 2005, p. 28). Whereas one definition in agricultural education cites this as a constructivist approach to instruction that revolves around real-world ill-structured problems (Jonassen, 1997). As this study looks at both science and agriculture teachers it is important to have field specific definitions.

**Problem-Solving Approach to Teaching:** The problem-solving approach to teaching, is often regarded as one of the most valued methods in agricultural education (Phipps & Osborne, 1998) and remains a primary teaching approach. The method involves students learning through problems, generally determined by the teacher or curriculum.

**Problem Solving Factors from the Problem-Solving Inventory:** the following definitions are based on the Problem Solving Inventory (Heppner & Peterson, 1982).

**Approach-Avoidance Style:** Approach-Avoidance style is defined as "a general tendency to approach or avoid different problem-solving activities" (Heppner & Peterson, 1982, p. 231). Approach-Avoidance style affects the problem-solving process in subsequent behaviors such as defining the problem or finding solutions and is related to personal agency.

**Personal Control:** Personal control is defined as "believing one is in control of one's emotions and behaviors while problem-solving" (Heppner & Peterson, 1982, p. 232). This often relates to how one reacts to problem such as jumping to conclusions or making snap judgments and regretting them later.

**Problem-Solving Confidence:** Problem-solving confidence is defined as "self-assurance while engaging in a wide range of problem-solving activities, a belief and trust in one's problem-solving abilities" (Heppner & Peterson, 1982, p. 231)

**Problem-Solving Levels:** Within problem-solving approaches, problem solvers will fall into two categories, novice or expert:

**Novice:** Novice problem-solvers quickly jump into quantitative expression and haphazard formula-seeking and solution pattern matching (Larkin, 1979). Novice problem-solvers are quick to write down numbers and make equations. Novice problem-solvers typically tend to use random facts and equations with little conceptual meaning (Reif & Heller, 1982), use multiple representations but do not understand why (Kohl & Finkelstein, 2008) and spend time finding making calculations and finding solutions (Schoenfeld, 1985).

**Expert:** In contrast, expert problem-solvers inject another step of qualitative analysis or low-detail review before writing down the equation (Larkin, 1979). Expert problem-solvers analyze what the question is asking in full, before moving on to the quantitative information, rather than solving with little conceptual knowledge. The way in which expert problem-solvers store principles in memory varies from novices as it is typically in chunks of information that are connected and can be applied together (Larkin, 1979). This allows them to finish faster with multiple, meaningful representations (Kohl & Fikelstein, 2008), take more time analyzing problem, and have the ability to look back at their solutions (Schoenfeld, 1985).

**Teaching Science as Inquiry (TSI):** An instrument developed to measure teachers' self-efficacy beliefs in regard to teaching of science as inquiry created by Smolleck (2004). The instrument consists of two major constructs: outcome expectancy and personal self-efficacy. Both are defined by Smolleck and Bandura (1997) as the following:

**Outcome Expectancy:** Outcome expectancy is defined as "a person's judgement of the likely consequences of one's own actions will produce" (Bandura, 1997, p. 21).

**Personal Self-Efficacy:** See personal self-efficacy in efficacy section of definitions.

# CHAPTER 2. LITERATURE REVIEW

## 2.1 Introduction

The focus of this chapter is a literature review related to problem-solving styles, approaches, and efficacy, as well as teaching self-efficacy and expectancy outcomes. A review of literature methodology will be provided in section 2.2. This chapter will also focus on outlining the theoretical and conceptual frameworks for the study.

## 2.2 Literature Review Methodology

The researcher collected literature from books and peer-reviewed journals relevant to the study via online libraries provided by Purdue University, and open access website such as Google Scholar. Select publications could only be accessed with affiliation to Purdue University and journal subscriptions the university holds. The review of literature includes publications from peer-reviewed journals, theses and dissertations, governmental references and publications, and practitioner resources.

Although the study focuses on agriculture teachers and science teachers, literature relating to problem-solving was defined broadly. Keywords in searches related to problem-solving included: problem-solving approach, problem-solving ability, problem-solving style, problem-based learning, problem-solving skills, and problem-solving approach to teaching. Additionally, key word searches specific to agriculture and science were used such as problem-solving in agriculture, problem-solving in science, agricultural problem-solving, science problem-solving, teaching-problem solving in agriculture, teaching problem-solving in science, and related searches.

Once a list of literature was collected, a systematic review was implemented in order to analyze only related topics as problem solving is a wide topic.

As this study focuses on teaching self-efficacy as well, an additional keyword search was conducted. Key words included: teaching problem-solving, self-efficacy teaching, self-efficacy teaching problem-solving, self-efficacy problem-based learning, teaching efficacy problem-based learning, and teaching problem-solving. Similar to searches conducted to problem-solving, discipline specific searches were also conducted. Once a list was collected, relevant literature was systematically reviewed.

## 2.3 Theoretical Framework

Bandura's Social Cognitive Theory and Self-Efficacy (1994) was the theoretical framework that guided this study. According to Bandura, self-efficacy beliefs are the strongest predictors of motivation and performance, therefore higher self-efficacy of teaching may lead to high performance of teaching problem-solving skills. As both problem-solving and teaching efficacy are related to one's self efficacy or belief in their own skill set and abilities, Bandura's theory of self-efficacy is an appropriate fit for this study. As this study was survey-based, teachers will be responded to questions regarding their perceived self-efficacy and skills. Bandura (1994) defined perceived self-efficacy as "people's beliefs about their capabilities to produce designated levels of performance that exercise influence over event that affect their lives" (Bandura, 1994, p. 71). Bandura further asserted that self-efficacy beliefs not only determine how people motivate themselves, but how they think, feel, and behave as well. Diverse effects can be seen through four major processes, cognitive, motivational, affective, and selection.

In problem-solving and teaching alike, self-efficacy is vital for taking on challenging and difficult tasks given they have high assurance in their capabilities. Bandura (1994) further describes the characteristics of individuals with a strong sense of self-efficacy. Individuals who have high assurance in their capabilities tend to approach difficult tasks as “challenges to be master rather than threats to be avoided” (Bandura, 1994, p.71). In relation to the Problem Solving Inventory (Heppner & Peterson, 1982), approach-avoidance styles in problem-solving are related to problem-solving confidence (assurance in one’s capabilities) and personal control. Bandura’s theory directly aligns with the variable measured by the PSI. Those that have a more approach-style to problem-solving feel secure in their capabilities and feel successful when problem-solving. Other characteristics include setting challenging goals and maintaining commitment, sustaining in the face of failure, quick to recover after setbacks and failure, and attribute lack of knowledge or effort to their failures. There is often a strong ability to exercise control and have assurance when facing threating situations.

Bandura’s (1977) Self-Efficacy Theory model outlines the interactions between a person, behavior and outcomes. Figure 2.1 illustrates of how these variables interact. A person’s behavior is influenced by their efficacy expectations, and those behaviors inform their outcome expectations. Outcome expectations then inform actual outcomes. Bandura (1977) differentiates between the two expectancies, efficacy and outcomes, as individuals believe that certain actions will produce certain outcomes. If they entertain doubts about whether they have the ability to perform said task, their behavior is not influenced by said information. Bandura’s original diagrammatic model does not include knowledge as one of the key structures but is a strong concept in the theory and relates heavily to the study. Knowledge helps guide what a person does with their skills and what expectations they have of that skill. The knowledge a person holds helps individual capabilities as it informs processes like problem-solving. Self-efficacy beliefs help determine how well knowledge and skills are acquired (Bandura, 1977). There is a direct relationship between self-efficacy and knowledge as they both influence the other. In relation to this study, a person's knowledge about problem-solving, as an expert or novice problem solver, will be apparent through how self-efficacious they feel to teach it. The skills and knowledge over time guide their behaviors and shape their efficacy expectations. The Problem Solving Inventory measures ones knowledge about problem-solving to determine mastery, which may be translated as high self-efficacy in problem-solving.

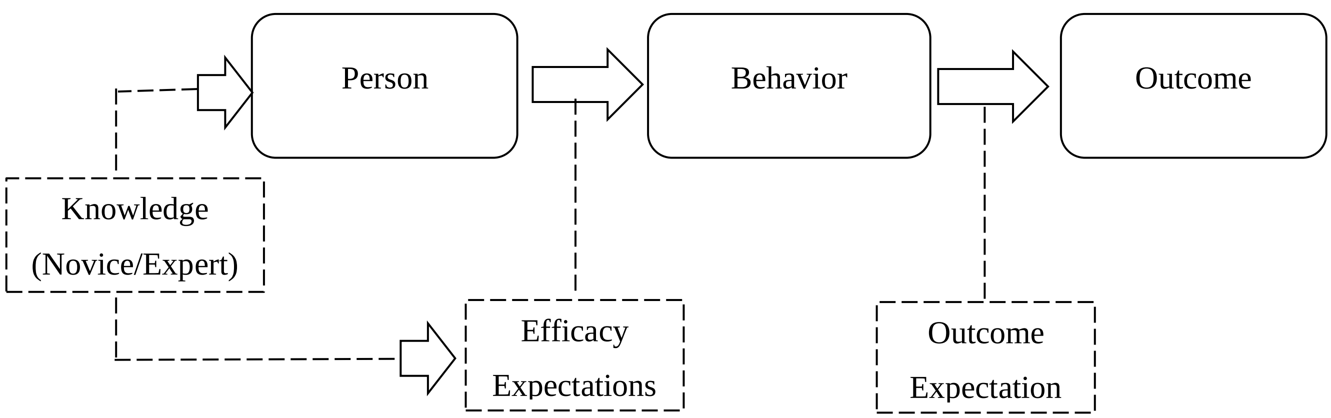


Figure 2.1 Modification of Bandura's diagrammatic model of differences between expectations, outcome and efficacy.

In contrast, Bandura (1994) elaborated on characteristics of individuals who demonstrate low self-efficacy and doubt their capabilities. Some major characteristics include low aspirations and weak commitments to goals, dwelling on personal deficiencies when faced with difficult tasks, focusing on adverse or negative outcomes rather than successfully performing, and give up quickly. Those with low self-efficacy are nearly the direct opposite of those with high self-efficacy as they slowly recover from setbacks, lose faith in their abilities after setback, and are often easily stressed and depressed (Bandura, 1994).

There are numerous ways to develop and strengthen self-efficacy. For example, mastery experiences, vicarious experiences by social modeling, strengthening beliefs in success, and by reducing negative emotions such as stress (Bandura, 1994). According to Bandura (1994), in order to establish a strong sense of self-efficacy, a person needs to experience success, as failure often undermines one's abilities. For example, if a person attempts to solve problems and fails more often than they succeed, their sense of self-efficacy will be weak if a strong sense isn't firmly established. Those who have a strong sense of self-efficacy will easily bounce back from failures and continue to solve problems rather than giving up and developing a low sense of self-efficacy. This same concept can be reflected in teaching as well, for example, having a successful lesson versus one that doesn't go so well. Having an imbalance of failures built upon a solid foundation of self-efficacy will result in resilience over failures, but if the foundation is poor, it will result in low self-efficacy.

The second way of strengthening beliefs about self-efficacy is through vicarious experiences through social modeling (Bandura, 1994). Often in education, vicarious experiences occur frequently in preservice training, through small group teachings and student teaching. In classroom peer-to-peer teaching, preservice teachers are able to develop a sense of positive self-efficacy teaching before stepping foot into a classroom on their own. These positive vicarious experiences are vital for developing teacher's sense of self-efficacy and beliefs. The same concepts exist in problem-solving. In an educational setting, learning in teams or partners, allows for natural vicarious experiences to occur. As students are paired together, they are able to learn from one another in a low risk setting.

The third way to strengthen self-efficacy and beliefs is verbal persuasion. Encouraging an individual that they have skills and abilities that equate to having characteristics of someone with high self-efficacy, over time their belief in themselves will increase (Bandura, 1994). Positive persuasion alone will not successfully develop efficacy as people need to succeed and avoid being placed in situations where they fail more often than they succeed. This relates to the fourth way to develop self-beliefs about efficacy, reducing stress and negative emotions. If there is stress and negative emotions regarding one's beliefs, self, or towards their abilities it creates a sense of doubt.

As these elements work together to develop one's self-beliefs, there is an element of structure involved in order to develop desired results. In the instances of problem solving, having mastery and vicarious through group work or experiential learning in which success is more often than not, learners can develop a sense of positive self-efficacy towards problem-solving. In order to properly measure this, participants must be asked using a scale that reflects beliefs and self-efficacy. Bandura's "Guide for Constructing Self-Efficacy Scales" (2006) guides the modifications of the instruments as it better aligns with the theoretical framework and more accurately reflects the research questions. Allowing participants to respond to statements with confidence-based responses suits the study and participants.

## 2.4 Conceptual Framework

To be successful as a practitioner, both a cognitive and practical apprenticeship must be fulfilled. In the process to become a teacher, many practical apprenticeships are completed, including student teaching and pre-service teacher development. Following this, in-service teachers continue their development by attending in-services and professional development events. Throughout these experiences learning skills, techniques and practices for preparing students with knowledge for action i.e., problem-solving skills is a focus for development (Jensen & Strømsø, 2017). Heppner and Petersen (1982) created a problem-solving inventory with the intent to measure three constructs within problem solving: problem-solving confidence (PSC), approach-avoidance style (AAS), and personal control (PS). Problem-solving confidence represents one's personal beliefs, self-efficacy, and trust in their own problem-solving abilities, approach-avoidance is a personals general tendency to approach or avoid problem-solving, and personal control, the extent to which individuals believe they are in control of their emotions and behavior while solving real-life problems. By measuring teachers' problem-solving styles, pre-service and in-service teacher development events can focus attention on developing problem-solving skills. As their problem-solving style, may have an influence on how they teach problem-solving, it is important that we explore where teachers are at. Bandura (1994) stated that a person needs to master skills to have high self-efficacy in said skill. Therefore, the PSI is used to try to measure teachers' problem-solving style and approach to explore whether they are expert or novice problem-solvers. They are experts, this might indicate they have higher problem-solving knowledge than those who are novice. If teachers tend to lack self-confidence and avoid solving problems, it may show in their teaching. An avoidance style is often a result of feeling unsuccessful in problem-solving. Again, we can relate this to Bandura's (1994) theory as a person needs to experience success to develop more approach styles of problem-solving. Those that have avoidance styles are less resilient whereas those who are more approach tend to bounce back after setbacks. As problem-solving is valued by employers and education, it is vital that students develop confidence and approach problems, rather than avoid them as they lack confidence. By measuring teacher ability to problem solve, there is potential to help develop more effective teachers.

In addition to the PSI instrument, a secondary instrument/study was necessary to determine teachers' self-efficacy towards teaching problem-solving. To measure this, a modified version of Smolleck's *Teaching Science as Inquiry* Instrument (2004) was used to explore self-efficacy teaching problem-solving. The instrument was modified to better fit the theoretical framework. Please see chapter 3.6.2 for more information. The instrument measured teachers' abilities to teach problem-solving in science disciplines, including agriculture. The instrument measured teachers' personal self-efficacy and outcome expectancies. Figure 2.2 outlines the independent and dependent variables in relation to the two instruments and targeted relationships. This conceptual framework aligns with Bandura's (1977) model of self-efficacy and outcome expectancies (Figure 2.1).

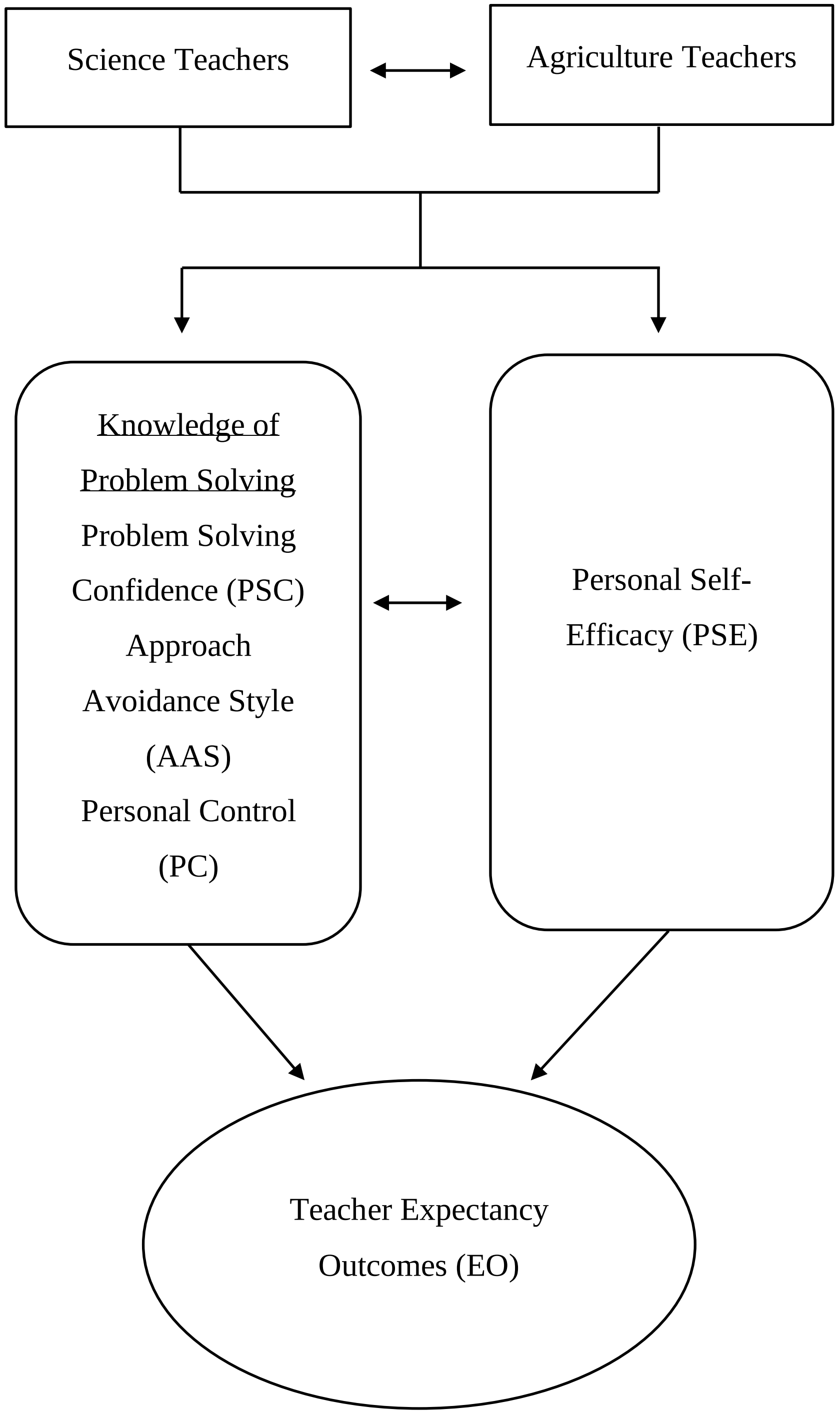


Figure 2.2 Conceptual Framework, relationship of variables

Attitudes and knowledge towards a problem are measured and interpreted by the variables problem-solving confidence, approach-avoidance style, and personal control (Heppner & Peterson, 1982). These variables are informed by domain-specific knowledge, as well as experience. As Bandura (1977) outlined a person's self-efficacy influences behavior, the variables PSC, AAS, and PC encompass those behaviors. Those behaviors inform their expectancy outcomes, and in turn outcomes. The variables from the Problem Solving Inventory are directly tied to Bandura's (1977) self-efficacy theory meaning the theoretical framework is connected to the conceptual framework.

## 2.5 Problem Solving

There are numerous ways to solve a problem, and just as many ways to teach others problem solving. Van Merrienboer (2013), stated that problem-solving is everywhere, from the clothes you wear, to what you eat for dinner, problem solving is present. Van Merrienboer continues by stating that problem-solving is not only an integral part of life, but makes people feel valuable (2013). Issues that arise with problem-solving and education is the way educators view them, either as cognitive methods or a domain of knowledge, skills to be learned. Some advocate learning problem-solving as an educational goal, while others focus on the educational method aspect. The problem-solving approach to teaching is a collection of methods that agricultural education uses heavily. Problem-solving is thought of as being the most important cognitive goal of education in every educational context: formal, informal, public schools, universities, and everything in between (Jonassen, 2010). Student experiences and real-life settings are vital, and the way in which students are problem-solving is brought to the forefront i.e. the problem itself rather than the method. In his article *Toward a Design Theory of Problem Solving* (2000), Jonassen states that problem variations (complexity, ill-structured, abstractness), the representation (context, cues/clues, modality), and individual differences (domain knowledge, structural knowledge, cognitive style, etc.) come together to create problem-solving skills. As problem-solving is thought of as such a necessary part to our educational system, or even everyday life, teachers need to have access and confidence to assist students in learning these skills.

### 2.5.1 Problem Solving in Education

There are many problem-solving instructional strategies that exist in literature. One source "An Evidence-Based Strategy for Problem Solving" (Woods, 2000), outlines over 150 different ways to problem-solve. The basic strategies in this article encompassed problem-solving strategies for engineering, design, business, science, mathematics, military, music, art, psychology, history, nursing, medicine, and policing. The strategies share commonalities like the use of acronyms or aids. Some strategies are developed based on strategies highlighted in the article. According to the article the nursing profession uses the same problem-solving techniques consistently, while other professions use variations or even multiple types of problem-solving in the same field. This is true for education, as teachers, school districts, or states may adopt certain standards and procedures they like while others select the methods they choose to use. The literature supports this as, most problem-solving strategies used are based on personal style, rather than research-proven methods (Woods, 2000). There are exceptions to this such as the medical field that relies on standardization but methods that teachers or everyday individuals use are reliant on personality rather than knowing multiple methods to do so.

Problem-solving in educational settings serve as the stimulus for students. It is regarded as an approach that meets the requirement for problem-based learning. While collegiate problem-solving focuses on the transmission of factual knowledge, K-12 has a different approach. In K-12 education, a tutor or teacher, assumes the role of a facilitator, and guides the students through problem-solving by posing questions to students in groups (Gijselares, 1996). Educational strategies and methods to teach problem-solving vary, but many researchers agree that it should feature elements of everyday contexts, using constructed knowledge in the context of problem solving or authentic situations, engaging, and support to solve the problem (Gijelaers, 1996; Jonassen, 2010; Van Merrienboer, 2013). As many have mentioned there is no “magic” or “one size fits all” method for teaching student how to problem-solve, as it is a very personal and individual skill (Scott & Bruce, 1995).

Jonassen (2010) puts the heavy problem of how to teach students problem solving on the shoulders of the instructional design and technology community and suggests using the elements of everyday contexts like work and personal lives (Gijelaers, 1996; Schoenfeld, 1985; Van Merrienboer, 1997), using knowledge constructed in the context of problem-solving or authentic situations, an international learning aspect, and finally engage and support learning to solve problems so the learning is not forgotten. The ideas that Jonassen puts forth are very similar to ideas that have been presented in other literature pieces, yet no one has really figured out the magic method to teach students how to problem-solve, perhaps because it is so personality based as Scott and Bruce (1995) suggested, there is no “one size fits all” method. Jonassen’s theory for problem-solving does not lie in the method, but the problem itself. As mentioned before, because the methods in which people problem-solve or make decisions is very unique, asking a well-developed problem over an ill-structed problem will support students’ problem-solving development skills better. Jonassen has written a handbook on designing problem-solving learning environments, and relates them to different ‘cases’, such as case studies, cases as analogues, and cases as prior experiences.

### 2.5.2 Problem Solving in Agricultural Education

In agricultural education, problem-solving and the problem-solving approach to teaching is regarded as the primary way to teach agricultural education (Phipps & Osborne, 1998). Perry, Retallick, and Paulsen (2014) outlined ideas centering around students mastering a new skill set emphasizing on critical thinking and problem-solving. The study went beyond problem-solving being an everyday occurrence and creates a benchmark. Rather than the skill being something students learn as they go through life, they created a tangible level of achievement in the acquisition of problem-solving skills. This emphasizes an idea that students need to practice problem-solving and master it by the time they reach higher education, as it is often identified by universities and employers as desired outcomes (Association of American Colleges and Universities [AACU], 2010, Easterly et al, 2017). Problem-solving and critical thinking skills are often grouped together as interconnected higher-order thinking skills (Doleck et al., 2017) as problem-solving processes play a vital role in critical thinking skills (Ulger, 2016). As Perry, Retallick, and Paulsen (2014) found, there is little research to be found regarding the critical thinking abilities that relate problem-solving of students in the college of agriculture (Rudd et al., 2000). Despite this being a widely accepted, and desired outcome of higher education, and developing in secondary education, a single definition for critical thinking skills does not exist (Sanders & Mouldenbelt, 2009) as how to teach problem-solving.

The problem-solving approach to teaching, which also is known as problem-based instruction, is an integral and historical method to teaching for agricultural education. Since the development of school-based agricultural education and developments from the Dewey era, (Moore & Moore, 1984) the problem-solving approach to teaching is a generational tool that has been used for decades. Moore and Moore (1984) described teaching problem-solving as a sophisticated teaching procedure, and to effectively teach problem-solving requires the teacher to motivate students, skillfully develop the problem, help students identify possible solutions, determine the correct solutions, and arrive at approved practices. They went on to describe expert teachers' ability to teach problem-solving like watching an artist work, as it came so naturally. Their methods were effective and concluded beautifully, with satisfaction from both teacher and students alike. It should be noted that the problem-solving approach to teaching is not just an individual method or technique, but an approach that utilizes a number of methods. Early career teachers struggled to incorporate as they were often more concerned with juggling courses, adjusting to the workload, and creating a suitable environment. This does not mean the novice teachers lacked self-efficacy in their problem-solving ability, but they did, however, have roadblocks in their integration of the technique (Buchanan et al., 2013). This indicates potential differences among novice and expert teachers. Further research would need to be conducted to address these differences as the study Moore and Moore (1984) completed, nor any studies thereafter addresses this.

In agricultural education, there are several methods and strategies used for modeling problem-solving practice. Some common approaches include generate & test, means-ends analysis, analogical reasoning, forked road & possibilities-factors, steps & key points, and four-question approach (Newcomb et al., 2004). Each method varies slightly depending on the goals of the teacher, lesson, or the desired practice such as declarative knowledge, contextualization, or transfer of skills. To operationalize the techniques, a short description of each of the methods is provided from Newcomb et al. (2004) and Rudd (2005). The generate and test method is best utilized when there are multiple solutions to a problem. In this instance, one's knowledge and experiences will be the primary support for solution testing. Means-ends analysis involve students analyzing current situations and comparing it to an idea situation, or the end goal. An analogical reasoning method emphasized transfer of knowledge and skills as students are tasked using a familiar situation to solve a problem in an unfamiliar situation. A forked road has students selecting between two choices, and possibilities-factors are multiple choices to decide which solution is best. Steps and key points are used for problems that require certain steps in order to solve the problem such as jump starting a vehicles dead battery or creating a plan of practice for a welding project. The last method, four-question approach is often mistaken as the problem-solving approach, but in reality is just one method. This method involves prompts to elicit responses based on experiences, real world examples or problems that students experience.

### 2.5.3 Problem Solving in Science Education

In science education, problem-solving has a slightly varied approach and is defined as "a planned sequence[s] of activities leading to a goal, the solution of the problem" (Taconis et al., 2000). Traditional teaching approaches in science education have further been described by Taconis et al.

> Traditional teaching approaches usually rely heavily on practicing problem solving on a large number of problems. Instruction and feedback are usually focused on the sequence of problem-solving steps to be performed and less emphasis on the knowledge and the cognitive strategies necessary to perform these steps (Taconis, 1995; Taconis et al., 2000).

As educational reforms often lead to new teaching practices, researchers in the 1980's introduced new methods of instruction to encompass a wider variety of learning tasks. Some were based on new cognitive process insights, while others were inspired by theories on the role of schemata in domain knowledge, mental models, or incorporating computers and communication technologies (Taconis et al., 2000). The 1980's emphasized the introduction of new teaching methods in relation to the changing technologies, just as STEM education and the introduction of 21st century skills are doing in modern times.

For science education, studies and articles related to teaching are often divided into content areas like chemistry, biology, and physics. This creates a large array of information both relating to teaching problem solving, but problem-solving in specific content areas. For example, Larkin and Reif (1979) examined teaching problem-solving in physics in terms of novice or inexperienced students before and after special instruction. To understand the problem-solving process further, especially in physics, student processes and solutions were compared to an expert, (a physics professor) to understand where difficulties were occurring in the process. In the novice learners process, their main model was to construct a description, construct a mathematical description, identify and apply relevant principles, and combine equations to eliminate undesired quantities. The expert process had twice as many steps, and began with construction a description, and then connecting it to theories and giving the problem a low detail 'physical' description. The expert problem-solver approached the problem theoretically, and then mathematically, where the novice skips this step entirely, or has tries to connect it to large laws and ideas. This expands on knowledge being a vital component to problem-solving, especially in terms of being an expert problem-solver. Of course, these methods are domain-specific for physics, a highly math integrated science application, but the same idea applies to various areas of problem solving in science, agriculture, and beyond.

In science education, problem-solving lessons are driven by phenomena, and involve the problem-solving method or the engineering design process. The methods are driven by the phenomena rather than practicing transfer of declarative knowledge or skills. The engineering design process is similar to problem-solving methods and techniques discussed in the agricultural education section but is more open to various applications. The engineering design process involves seven steps: 1. Ask to identify the need and constraints, 2. Research the problem, 3. Imagine possible solutions, 4. Plan by selecting a promising solution, 5. Create a prototype, 6. Test and evaluate the prototype, and 7. Improve and redesign as needed (NGSS, 2016). This is one method a teacher might use when teaching a problem-solving lesson relating to phenomena, as the emphasis is more about figuring something out rather than just learning about it.

### 2.5.4 Summary of Problem-Solving in Agriculture and Science

Agricultural education and science education use specific definitions regarding problem-solving teaching. This results in distinct methods as a result that are field and domain specific. Table 2.1 outlines major differences between definitions and teaching methods from agricultural education and science education.

Table 2.1 Comparison of definitions and strategies for teaching problem solving in agriculture and science

| | **Agricultural Education** | **Science Education** |
|---|---|---|
| Definition for Problem Solving Teaching | "An approach to teaching that provides students with the opportunity to move from declarative (facts and beliefs), contextual (knowledge about agriculture) and procedural (knowledge about agricultural process) knowledge to more complex processes like problem solving…" (Rudd, 2005) | "A planned sequence[s] of activities leading to a goal, the solution of the problem" (Taconis et al., 2000) |
| Teaching Strategies | Multiple specific strategies and methods including generate & test, means-ends analysis, analogical reasoning, forked road & possibilities-factors, and four-question approach (see section 2.5.2 for further explanations of each approach) | Engineering design process—ask, research, imagine, plan, create, test, and improve (NGSS, 2016).<br><br>Problem-solving method |

## 2.6 Teacher Efficacy

Self-efficacy stems from Bandura's social cognitive theory (1994) and is a person's beliefs concerning their ability to perform a task or behavior. Their beliefs not only determine how people might think or feel, but it also motivates how they behave. If a person has a strong sense of self-efficacy, they may experience higher levels of personal well-being or complete harder tasks and challenges. Typically, they quickly recover after failures or setbacks as they attribute it to not knowing enough information or have enough training. The person does not believe they will never be able to do it, but it might take more attainable training or knowledge to complete it. As self-efficacy is perceived, it can increase or decrease depending on the person, and their development through four main sources. These sources include mastery experiences, vicarious experiences, social persuasion, and modifying self-beliefs (Bandura, 1994). The most impactful of the four is typically mastery experiences, where failure and success is an ebb and flow, developing the skills necessary to deal with failure.

Nearly all of these principles can be related to teacher preparation education and teaching practices in general. Self-efficacy of a teacher is often referred to as teaching self-efficacy or teacher efficacy and is most commonly defined as: the teacher's belief in their capability to organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context (Tschannen-Moran et al., 1998). Teacher efficacy stems from Bandura's social cognitive theory (1977) and Rotter's social learning theory (1966). Tschannen-Moran et al. (1998) combined these similar, yet intertwined works to create a uniform theory of teacher efficacy. For teacher efficacy, although similar to self-efficacy, as previously stated, is a direct reflection on the teacher's ability to impact students. To be able to determine this, a number of instruments have been created including the RAND measure (1979), Teacher Locus of Control (Rose & Medway, 1981), the Teacher Efficacy Scale (Gibson & Dembo, 1984), and Bandura's Teacher Efficacy Scale. Many are 5 or 7-point Likert scales, and include statements such as "When a student gets a better grade than he usually gets, it is usually because I found better ways of teaching" and "How much can you do to get children to follow classroom rules?" Many feature questions relating to the teachers' direct influence on classroom best practices, environment, and student impact, as well as questions regarding school climate, parents, and local colleges and universities. Many of the featured scales have been translated into subject specific inventories such as the Science Teaching Efficacy Belief Instrument (STEBI) by Riggs & Enochs (1982), which was developed from Gibson and Dembo's Teacher Efficacy Scale (1984).

In addition to outlining and creating measures of teacher efficacy, Tschannen-Moran et al. (1998), outlined the meaning of teacher efficacy and conceptual meanings. Powerful constructs related to a teachers' sense of efficacy include student outcomes such as achievement, motivation, and their own sense of self-efficacy (Tschannen-Moran et al., 1998). In a classroom, this might be reflected in the teacher's behaviors, such as the effort they put into teaching, goals set for themselves and their students, and levels of aspiration. Teachers with a high level of efficacy are often more experimental as they are resilient to failure or setbacks and create learning opportunities from them (Tschannen-Moran et al., , 1998). Along with resilience to failures or setbacks, teacher with a strong sense of efficacy tend to be more patient with students, working longer with those that are struggling rather than sending them to special education service or moving on. Additionally, these teachers try to create positive environments around them in relation to the health of the organizational climate, and classroom climate (Tschannen-Moran et al., 1998). As teacher efficacy originates from self-efficacy, there is also a level of personal self-efficacy involved, as teachers need to be confident in their own knowledge to be able to teach others.

### 2.6.1 Teacher Efficacy and Problem Solving.

For topics like math and science, there is a large amount of literature to support what teaching efficacy looks like for each field (Angle & Moseley, 2009; Khourey-Bowers, & Simonis, 2004; Sawtelle, et al., 2012; Savran & Carkiroglu, 2001). However, there is limited information in regard to measuring efficacy and effectiveness of problem-solving as a complex skill. Problem-solving can be treated as simple or a complex skill, where more than one method might be utilized. Many instructional design models offer guidelines and trainings for one-dimensional problem-solving skills, rather than complex, multi-dimensional skills (Van Merrienboer, 1992). To address this gap, van Merrienboer outlined a Four Component (4C) instructional design model for teaching complex skills. Although it does not necessarily outline what a teacher with high efficacy looks like, it does outline what an effective teacher should be accomplishing to teach complex skills.

### 2.6.2 Teaching efficacy in agriculture.

Many studies, especially in agriculture, teaching efficacy falls within preservice or novice teaching studies. Recalling Knobloch's study (2001), significant gains were found in developing teaching efficacy through peer teaching as preservice teachers. Not only does teacher self-efficacy impact success throughout one's career, it impacts student achievement, job satisfaction, and teacher retention (Korte & Simonsen, 2018). Lower teacher efficacy was a primary reason teacher's chose to leave education, where those with higher self-efficacy continued to stay despite hardships, difficulties and unmotivated students (Korte & Simonsen, 2018). As teacher retention is a growing problem for agricultural education, it is important to support teachers' continuing education and development of self-efficacy especially during formative years i.e. novice teaching years. Korte and Simonsen (2018), found that a perceived sense of support from school administrators, parents and students largely contributed to their sense of self-efficacy. Due to the fact that agriculture is typically an elective course and has intra-curricular activities (SAE's and FFA), support from parents and school administrators is highly valued for the success of the program.

Swan, Wolf, and Cano (2011), conducted a longitudinal study of changes in teacher self-efficacy from student teaching to the third year of teaching. Participants were measured based on overall self-efficacy, student engagement, instructional strategies, and classroom management. The point in which teachers experienced the highest levels of self-efficacy was during the student teaching experience and second year, while the lowest were typically the first year and the third year. Classroom management in particular had a steady decrease over time, while the other three factors had alternating levels of efficacy throughout the four years measured. The researchers attributed the high levels of efficacy during the student teaching period to receiving support from a mentor and promoted retention in the profession. The declines in the first year of teaching, were attributed to the lack of a mentor present. This is a common finding with teachers in many disciplines, not just agriculture as Woolfolk Hoy & Burke-Spero (2005), had similar findings in science education. Teacher beliefs and self-efficacy is not a stable or constant variable, it is ever-changing aspect of teaching.

### 2.6.3 Teaching Efficacy in Science

In science, ideas of self-efficacy and outcome expectancy beliefs, of Bandura's theory (1977) are common and well developed. Instruments such as the Science Teaching Efficacy Beliefs Instrument (STEBI) have been developed to measure personal science teaching efficacy beliefs and science teaching outcome expectancy (Riggs & Enochs, 1990). The instrument asked questions such as "I am continually finding better ways to teach science" or "I find it difficult to explain to students why science experiments work." These questions were designed and guided by literature to measure personal science teaching efficacy and outcome expectancy beliefs.

Ginns and Watters (1990) explored science teaching efficacy in preservice elementary teachers. Teacher candidates expressed that their inadequacy in teaching science may manifest itself in the form of poorly designed lessons that were ineffective. Ginn and Watters (1990) found that teachers had a positive relationship with science when a hands-on or memorable activity was the focus. For example, one participant distinctly remembered an activity that involved rolling bottles full of different liquids down a ramp. These positive recollections were the result of engaging activities that generated enthusiasm. Activities or lessons that only had students taking notes from a chalkboard failed to spark the same enthusiasm and resulted in negative recollections towards science.

Avraamidou (2014) expressed similar findings when examining future science teachers' identity development. When preservice teachers had positive memories of science from their youth (elementary and secondary school age), they had positive identities associated to science. Those that did not and felt that science teachers were often "nerdy middle-aged men" had more negative associations. Those with more negative emotions did not necessarily hate science, but it was not their favorite subject and they had doubts about being efficacious while teaching the subject. Following positive experiences as an undergraduate preservice teacher, their outlook and associations with science began to change. Following these positive experiences, preservice teachers were excited to teach science, as they felt more efficacious towards teaching the subject; for the reason of aligning Bandura's (1994) suggestions on the development of beliefs, mastery experiences and vicarious learning experiences. Through these mastery and vicarious experiences, preservice teachers with low self-beliefs were able to develop positive associations and in return higher self-beliefs towards science teaching.

# CHAPTER 3. METHODOLOGY

## 3.1 Introduction

This chapter will discuss methods, procedures, and analysis plans for data to be utilized in this study. A brief overview of the purpose and research questions will be provided in order to elaborate on the research design further in the chapter. The Institutional Review Board process, protocol number, and risks to participants will be discussed. A major section of this chapter outlines the instrumentation used for this study and constructs that exist. Additionally, this chapter will outline and describe the participants, pilot testing, data collection and data management for this study.

## 3.2 Purpose and Research Questions

The purpose of this study was to explore and describe agriculture teachers and science educators perceived problem-solving approaches, and their self-efficacy towards teaching problem solving to students influence on each other. This study was guided by three research questions with the goal of determining how science and agriculture teachers approach problem-solving, how they differ, and how their perceived self-efficacy towards teaching problem-solving. The three research questions are:

1. What approaches do agriculture teachers and science teachers have towards problem-solving?

2. What level of self-efficacy do agriculture teachers and science teachers hold towards teaching problem-solving?

3. What relationships exist between problem-solving approaches (PSC, AAS and PC) and efficacy towards teaching problem-solving (PSE and EO) in agriculture teachers and science teachers?

3a. What percent of variability in the sum of variables (i.e., PSC, AAS, PC, and PSE) are related when regressed towards teacher's expectancy outcomes?

3b. Do the same relationships exist for agriculture teachers and science teachers?

## 3.3 Research Approval

To protect participants rights, the researchers completed the Collaborative Institutional Training Initiative (CITI) course in the Protection of Human Research Subjects online training module. Following completion of this module, an application containing all materials i.e. instrumentation, research questions, target populations, was sent to the Institutional Review Board (IRB) and the Committee on the Use of Human Research Subjects at Purdue University was sent by the researcher team. The committee found the study to be no more of a threat than daily life and was approved for exemption status. The study "*Agriculture and Science Teachers Problem Solving Approaches and Relation to Teaching Efficacy"* was approved *(IRB protocol:* 2019-901) on January 13th, 2020. A copy of the approval can be found on Appendix A.

## 3.4 Research Design

The purpose of this research was to determine if teacher problem-solving style influences teaching efficacy beliefs in regard to problem-solving. The research examined science teachers and agriculture teachers to determine if there were differences between the two groups in addition to defining how they approach problem-solving and their level of self-efficacy. To address this, an online Qualtrics questionnaire was developed to describe these phenomena quantitatively. The intent of the survey was to explore potential relationships, not to make generalizable claims, resulting in a focused distribution across three states. The survey was divided into three major sections: (1) Problem Solving Inventory, (2) Teaching Science as Inquiry, and (3) Demographics. Demographics was placed at the end of the survey following recommendations from Dillman et al. (2014). To increase response rates, participants received an initial email, followed by a reminder email one week from the initial email date.

## 3.5 Participants

Participants for the survey were convenience samples from three states, Iowa, Indiana, and Ohio. The participants were current high school science and agricultural teachers. For this study, science included biology, chemistry, physics, earth and space science, and environmental science. As participants were given an "other" field for a response option, there may be more areas not yet known to the researchers. Participants were at various stages in their professional career and have various amounts of knowledge. Surveying these three states provided a diverse enough pool to generate comparisons. See Chapter 4, section 4.4 for a more detailed breakdown of the participants.

Two groups, science and agriculture teachers were selected in order to compare how teachers in each group approach problem-solving and how efficacious they feel teaching problem-solving. In both science and agricultural education, the problem-solving approach to teaching is used, more often in agricultural education, as inquiry-based learning is the dominant strategy in science education.

## 3.6 Instrumentation

Two instruments were used in this study, the Problem Solving Inventory (Heppner & Baker, 1997), which was an unmodified previously validated instrument, and a modified version of the Teaching Science as Inquiry instrument (Smolleck, 2004). In addition to these instruments, a section of demographic questions addressing basic, non-identifying information was also included.

### 3.6.1 Problem Solving Inventory (PSI)

The Problem Solving Inventory (PSI) is described as an assessment of “an individual’s awareness and evaluation of his or her problem-solving abilities, and thus provides a global appraisal of that individual as a problem-solver (Heppner & Baker, 1997, p. 231)”. The survey consists of 32 six-point Likert items, but was changed to a 5-point scale, with the response options of “never, seldom, sometimes, quite-a-bit, and always”. Similar studies have made the same modification and were still reliable and valid (Chan, 2001; Kourmousi et al., 2016). In this study, the instrument was adjusted to a 5-point scale to be able to compare results to the Teaching Science as Inquiry instrument (TSI) (Smolleck, 2004). Additionally, a 5-point, one-way confidence scale is recommended by Bandura (2006), for measuring self-efficacy and is the conceptual framework for this study.  Validity and reliability test were conducted due to the modified scale, but there is literature to support the adjustment made to this instrument, such as Chan (2001), and Kourmousi et al. (2016). The results of the test are illustrated on table 3.1.

The PSI is comprised of three factors: Problem-Solving Confidence, Approach-Avoidance Style, and Personal Control. The author, Heppner & Baker (1997), describes the constructs as such:

> Problem-Solving Confidence is defined as self-assurance while engaging in a wide range of problem-solving activities, a belief and trust in one’s problem solving abilities…Approach avoidance Style [is] defined as a general tendency to approach or avoid different problem-solving

> activities….Personal Control [is] defined as believing one is in control of one's emotions and behaviors while problem solving (p.231).

The authors further elaborate on these factors. The first factor, problem-solving confidence, is positively associated with personal agency and curiosity while negatively associated with anxiety, depression, and even eating disorders. This is where coping methods come into the equation, as those who have positive coping mechanisms in relation to problem-solving have more confidence, whereas negative coping mechanisms such as shutting down, have low levels of confidence. The second factor, approach-avoidance style, indicates that higher scores are correlated with avoiding problems where lower scores correlate to approach styles. Having an approach-avoidance style affects the problem-solving process in relation to defining the problem and seeking solutions. The third factor, personal control, is similar to problem-solving confidence as positively associated with personal agency and again, negative associations with anxiety and depression.

As the survey is all based on perceived problem-solving skills, it may not accurately reflect their actual problem-solving skills. The survey was noninvasive and does not require participants to solve problems while answering the questions which allowed for the survey to be distributed digitally. Despite the survey collecting self-identified perceived abilities, there is empirical evidence that there is a direct connection between self-appraised skills and performance (Heppner et al., 1995).

### 3.6.2 Teaching of Science as Inquiry

The second instrument, Teaching Science as Inquiry (TSI) (Smolleck, 2004), is an instrument originally intended to measure self-efficacy beliefs in regard to teaching science as inquiry. As no instrument for self-efficacy towards teaching problem-solving exists, the survey was modified in order to accurately reflect problem-solving rather than inquiry as the approach. As the scale is based on the essential features of inquiry from the National Research Council (NRC, 2000), and is one of the Next Generation Science Standards (NGSS) (2013), replacing inquiry with problem solving were followed these guidelines. Additionally, problem-solving is part of the NGSS essential eight practices, and both inquiry and problem-solving are in the same category for 21st Century Skills. All replacements of the instances of "inquiry" with "problem-solving" was reviewed by two content experts and was deemed to be correct and accurately measuring the desired response. For example, "I possess the ability to allow students to devise their own problems to investigate" was modified to reflected problem-solving by stating "I possess the ability to allow students to devise their own questions to investigate problems." In some instances, problem-solving and inquiry were not directly replaced, but were replaced by procedure specific vocabulary. In the NGSS eight science and engineering practices, it uses "question (inquiry)" or "problem (engineering design)", and "explanation (inquiry)" or "solution (engineering design)" to distinguish inquiry and engineering design practices. The researcher followed the NGSS (2013) eight science and engineering practices as the guideline to modify the TSI. For example, "My students will comprehend teacher presented explanations" was modified to reflect problem-solving and now states, "My students will comprehend teacher presented solutions".

The survey consisted of 69, 5 point-scale Likert type items, which again, were modified to reflect Bandura's confidence scale (2006) with the same fields as the PSI. Rather than having participants state "strongly agree" to "strongly disagree" the scale was revised to state "never, seldom, sometimes, quite-a-bit, and always", which was recommended by Bandura (2006). The 69 questions constituted two constructs, personal self-efficacy and expectancy outcomes, with five essential features: (1) Learner Engages in Scientifically Oriented Questions, (2) Learner Gives Priority to Evidence in Responding Questions, (3) Learner Formulates Explanations from Evidence, (4) Learner Connects Explanations to Scientific Knowledge, and (5) Learner Communicates and Justifies, interact among each other. The survey once modified, was analyzed using the pilot test group to determine reliability and validity of the responses.

### 3.6.3 Demographics

In order for comparison between science teachers and agriculture teachers, participants were asked a series of questions regarding their certification status, highest degree, current teaching licensures, certificates held, and years taught. Participants were asked if they taught science, agriculture, both or other, and based on their response a secondary set of questions appeared. If participants selected science, they were asked what specific area of science they teach, if they selected agriculture, they were asked if they held additional certificates such as Curriculum for Agricultural Science Education (CASE) curriculum. If participants selected having taught both agriculture and science, both sets of questions would appear. Participants were not shown questions that did not apply to their specific area (science or agriculture) to reduce confusion with jargon. Participants were also asked basic non-identifying questions such as age group, gender, state where they taught currently, how many years they have taught and what type of area they taught in (rural, urban, etc.) according to the United State Department of Agriculture (USDA) definitions (USDA, 2019).

## 3.7 Survey Error, Validity, and Reliability

### 3.7.1 Problem Solving Inventory

As the PSI was a previously validated and reliable instrument, it would normally not be necessary to re-validate the instrument. However, the instrument was modified from a Likert Scale to a one-way confidence scale following Bandura’s self-efficacy scales (2006). The new response options included never, seldom, sometimes, quite-a-bit, and always. As these options more accurately reflect the research questions and align with the theoretical framework, tests for reliability were performed before distribution and were found to be valid and reliable. A Cronbach’s alpha test was performed for each factor in the survey to ensure that the modification from a 6-point scale to a 5-point scale held validity. Table 3.1 outlines the Cronbach’s Alpha test for internal reliability of the factors after modification. As the value of Cronbach’s Alpha was above x=0.80, it can be determined that the internal consistency of the instrument was maintained.

Table 3.1 Cronbach's Alpha for Problem Solving Inventory Variables

| Survey Factor | Number of Items | Cronbach's Alpha |
|---|---|---|
| Problem Solving Confidence | 11 | 0.876 |
| Approach Avoidance Style | 16 | 0.860 |
| Personal Control | 5 | 0.856 |

### 3.7.2 Teaching Science as Inquiry

*3.7.2.1 Content Expert Analysis*

Modifications to the Teaching Science as Inquiry (TSI) inventory were analyzed by content experts to determine if the questions content upheld reliability. All changes by the researcher were reviewed and edited by content experts. All 69 items were systematically reviewed, most often, minor changes were made to questions as inquiry and problem-based learning are similar in nature.

Once the survey was analyzed and revised by experts, a more thorough statistical analysis was completed including Cronbach's Alpha test for internal reliability.

### *3.7.2.2 Cronbach's Alpha Test for Internal Reliability*

As the TSI survey was modified, it was important to ensure the validity and reliability were maintained for the constructs, as well as clarity and comprehension for participants. An initial test for internal reliability using Cronbach's Alpha was conducted. Table 3.2 outlines each construct, and the reliability of each principle factor within the constructs. Questions for the two constructs, Person Self-Efficacy and Expectancy Outcomes were derived from each of the five principles. Although the questions did not overlap, testing each principle internal reliability with each construct was necessary to ensure consistency of the constructs and questions. As the questions were modified in order to reflect problem solving, the original instrument Cronbach's Alpha level was included, as recommended by Creswell (2009) in the table to ensure that the modified instrument-maintained reliability.

Table 3.2 Teaching Science as Inquiry Variables Cronbach's Alpha Original and Modified Instrument Values

| TSI Factor | Original Instrument Cronbach's Alpha Reliability Results | Modified Instrument Cronbach's Alpha Reliability Results |
|---|---|---|
| *Personal Self-Efficacy Construct* | | |
| Learner Engages in Scientifically Oriented Questions | $\alpha$=.69 | $\alpha$=.870 |
| Learner Gives Priority to Evidence in Responding Questions | $\alpha$=.68 | $\alpha$=.89 |
| Learner Formulates Explanations from Evidence | $\alpha$=.74 | $\alpha$=.826 |
| Learner Connects Explanations to Scientific Knowledge | $\alpha$=.62 | $\alpha$=.875 |
| Learner Communicates and Justifies | $\alpha$=.65 | $\alpha$=.959 |
| *Expectancy Outcomes Construct* | | |
| Learner Engages in Scientifically Oriented Questions | $\alpha$=.80 | $\alpha$=.891 |
| Learner Gives Priority to Evidence in Responding to Questions | $\alpha$=.75 | $\alpha$=.857 |
| Learner Formulates Explanations from Evidence | $\alpha$=.78 | $\alpha$=.923 |
| Learner Connects Explanations to Scientific Knowledge | $\alpha$=.80 | $\alpha$=.774 |
| Learner Communicates and Justifies Explanations | $\alpha$=.78 | $\alpha$=.83 |

## 3.8 Pilot Test

A pilot test was conducted prior to distribution of the survey to determine validity, reliability, and troubleshoot any issues. Creswell (2009) recommended pilot testing instruments that are new or have been modified as the reliability and validity may change. The pilot study was conducted utilizing twenty-three undergraduate agricultural education students, two agricultural educators in states not surveyed from Minnesota and Wisconsin and three graduate level science education students. In total there were 28 participants in the pilot test for this study. These groups were convenience samples and selected for their field expertise.

### 3.8.1 Undergraduate Agricultural Education Students

The undergraduate agricultural education students, who took ASEC 319 Program Planning for Agricultural Education Programs in Fall 2019, participated in the pilot study. The students who took this course were also considered as pre-service agricultural teachers. Students were provided the email link to the Qualtrics survey from their professor and could also access the survey link on the course Blackboard page for students unable to attend class. Undergraduate students provided feedback on survey flow and clarity, as well as length, time to complete, and functionality.

### 3.8.2 Graduate Science Education Students

Science education graduate students, who took EDCI 517 Survey of Science Education class in fall 2019, participated in the pilot study. Most graduate students were former teachers from various science backgrounds including biology, chemistry and physics. There were also several pre-service teachers from biology, chemistry, and physics as well. Pre-service teachers held a bachelor’s degree in a science discipline and were seeking formal teacher training to become K-12 teachers. Graduate students were sought out for subject specific comments, as the researcher’s primary field is in agricultural education. Students were emailed the link directly and experienced the same survey as those from agricultural education. The survey was intended for a pilot study, so responses were kept separate from a final version of the survey.

### 3.8.3 Agricultural Educators

Agricultural educators who participated in the pilot study were in-service educators from Minnesota and Wisconsin and were personal contacts of the researchers. As Minnesota and Wisconsin were not states of interest and being sent the survey, their results were kept separate from the study as well. In-service agricultural educators were sought to confirm field specific questions, and to ensure that questions regarding science were applicable and reflected current practices. Again, teachers also commented on length of time took to complete, clarity, and function of the survey.

### 3.8.4 Feedback

Pilot test participants were able to test skip logic, open-ended and multiple-choice question types. Although most of the feedback was positive, there were a number of participants who commented on the length of the survey, as the first block was 32 questions (PSI) and the second was 69 questions (TSI). Additionally, there were comments regarding missing field titles, clarity, and the repetitive nature of the questions. Although the researcher did not address the comment relates to the length of the survey, the researchers addressed these concerns in the final copy of the survey. The survey was not shortened due to concerns over reliability and validity as the instrument had not been tested otherwise using the modified questions. In response to feedback, the structure of the survey was revised for participant ease. Missing headers were corrected, and broken skip-logic functions were resolved. As many participants commented on the length of the survey, there were not enough changes to create a shorter survey. In order to preserve the instruments, all questions were kept despite participant comments on similar sounding questions.

## 3.9 Data Collection

Survey distribution and data collection was conducted via a digital Purdue University Licensed Qualtrics-based survey. The survey was available to participants beginning January 28th, 2020 and was open for three weeks. As previously stated, participants for the study were agriculture and science teachers. The databases for agricultural education participants were obtained from previously relationship with State Agricultural Education Leaders. Many states, including Indiana, Iowa, and Ohio have a statewide email listserv, which was utilized for this study. Teachers choose to participate in the listserv, so all agriculture teachers state-wide may not have been included, but a majority of teachers do elect to be included in the listserv.

For science education, a statewide listserv does not exist. Participants emails for this study were obtained through publicly-posted email addresses on school websites. For this study, only public schools listed in the state database were utilized. The researcher went to each school's website and identified science teachers' (broadly defined) email addresses and created a state address book in Qualtrics. If additional steps were required to obtain an email address like typing the email in the website itself, or logging in to the school's website, the school was not included in the study. This created a limitation as it is not all schools in the state, only those that publicly post their teacher's email addresses. This method was IRB approved, and the contact list was password dual authentication, password protected in order to protect participant privacy. Only email addresses were collected as part of this study, names or schools were not recorded in order to retain confidentiality.

After the first week, a reminder email was sent to participants that did not respond to the initial invitation to the survey or had not yet finished their survey from the original email. To avoid survey fatigue, the researcher only sent one reminder email to participants. Table 3.4 showed the contact occasions that are outlined on. The initial email detailed the reason for the survey, an overview of the survey and estimated time to complete, and contact information for the researchers. An anonymous link for the survey was included in the email, in which IP addresses, email addresses, or names were not collected to protect the participants identity.

Table 3.3 Qualtrics Email Survey Link Invitations to Agriculture and Science Teachers

| Date | Time | Purpose |
|---|---|---|
| 01/28/2020 | 6:00 PM | Initial invitation to participate in study |
| 02/05/2020 | 12:29 PM | Reminder to unfinished respondents |

In total there were 2,979 initial emails sent to science teachers in Indiana, Iowa, and Ohio on January 28th, 2020 and of those 84 bounced, and 12 failed by either email server response or invalid/inactive email account. During the second attempt on February 5th, 2020 there were 2,741 reminder emails sent, of which, 85 emails bounced, and 11 failed. This is outlined on Table 3.5.

Table 3.4 Email Distribution Summary of Science Teacher Reponses by State

| State | Date | Emails Sent | Emails Bounced | Emails Failed |
|---|---|---|---|---|
| Indiana | 01/28/2020 | 1122 | 35 | 11 |
| Indiana | 02/05/2020 | 1010 | 36 | 11 |
| Iowa | 01/28/2020 | 525 | 12 | 0 |
| Iowa | 02/05/2020 | 493 | 12 | 1 |
| Ohio | 01/28/2020 | 1329 | 37 | 0 |
| Ohio | 02/05/2020 | 1238 | 38 | 0 |

Agriculture teachers were surveyed at the same time as science teachers, and in total 1,117 emails were sent between Indiana, Iowa, and Ohio. In agreeance with Purdue Faculty, who maintain the listserv, an email containing the link could be sent out to teachers, but no email addresses were viewed or received by the researcher. As a result, there was a maximum number of emails sent for both the initial and reminder as accurate counts could not be conducted. This applied to emails bounced and emails failed as well as there was no way to tell in Qualtrics or through the Listserv how many bounced, failed or were received but not responded to. Between Iowa and Ohio, 25 emails bounced following the initial invitation and 25 following the reminder email. There were 6 emails that failed initially, and then 5 following the reminder email. Connections made between the researcher and agriculture teachers can be seen in Table 3.6.

Table 3.5 Email Distribution Summary of Agriculture Teacher Reponses by State

| State | Date | Emails Sent | Emails Bounced | Emails Failed |
|---|---|---|---|---|
| Indiana | 01/28/2020 | 307* | * | * |
| Indiana | 02/05/2020 | 307* | * | * |
| Iowa | 01/28/2020 | 312 | 16 | 5 |
| Iowa | 02/05/2020 | 286 | 16 | 4 |
| Ohio | 01/28/2020 | 498 | 9 | 1 |
| Ohio | 02/05/2020 | 467 | 9 | 1 |

*Note.* Researchers did not have direct access to an email contact list and a link was sent through a state-wide listserv. A maximum number was recorded for both dates as there is no data from Qualtrics to determine how many emails bounced, failed, or were sent either times.

As contact information was embedded in both the initial survey email, reminder survey email, and the survey itself, in the event of a participant having a question about IRB, the survey, or a general question about the study. All correspondences between the researcher and participants were saved, cataloged and kept in a password protected account. On Table 3.7, emails received by the researcher were broadly categorized.

Table 3.6 Catalog of Emails between Participants and Researchers

| Reason for Correspondence | |
|---|---|
| Expressing Interest in Survey Results | 4 |
| Further Comments on Problem Solving/Teaching | 4 |
| Disgruntled/Did not want to participate | 7 |
| Issue with survey | 1 |
| Would like more time to complete survey | 1 |
| Alerted Researcher of Completed Survey | 3 |

Many of the participants that did respond to the survey were eager to complete the survey and were interested in receiving results following the study. Several participants offered insight and feedback regarding how they utilize problem solving in their classrooms, the importance of problem solving to them and their students, and improvements that could be made to education. Several participants replied to the researcher to alert them that they did not want to participate in the study for various reasons including that it was "too long", "they did not have the time" or they simply "did not want to". Several participants sent a courtesy email to the researcher to alert them that they had completed their responses, and one participant requested more time and sent several update emails regarding progress made over time.

In total, there were 507 number of participants that engaged with the survey in some manner. This could have been opening the survey, responding to one question and then closing the survey. See table 3.7 for an accurate reflection of participants who responded based on state, subject, and the total amount after cleaning. Only participants who completed at least the first two sections and could be properly identified as being science or agriculture were included in data analysis. The final response rate for the survey was 9.04% for agriculture teachers and 13.4% for science teachers. After data cleaning there was a total of 4.3% of useable responses from agriculture and 5.58% for science. The response rate is lower than desired, but still holds value as the study does not intend to generalize.

Dillman (2014) recommends offering an incentive to completing surveys like a coupon or a chance to win a gift card, no incentive was offered. This could potentially result in a number of survey errors as only participants who took the unincentivized time to fill out the survey will be collected. If an incentive were offered, the response error might be less of a threat. Those who respond to the survey may be similar as they did not fill out the survey in order to obtain an incentive. Other survey errors include participants not having access, teachers not understanding or misinterpreting the questions, or not reading the survey carefully enough.

Table 3.7 Participant responses by state and subject area. All fields expressed as (n = x)

| State | Agriculture | Total after cleaning | Science | Total After Cleaning |
|---|---|---|---|---|
| Indiana | * | 4 | 181 | 72 |
| Iowa | 39 | 15 | 60 | 29 |
| Ohio | 62 | 30 | 158 | 65 |
| Total | 101* | 49 | 399 | 166 |

*Note:* Again, initial participation for this cannot be accurately reflected due to the nature of the contact list, only those that finished the survey up to the point of self-reporting their state and subject taught.

## 3.10 Data Management

As data were collected through Qualtrics, two factor authentication was utilized to access data, allowing only the researchers to access the data. Any data that were exported were password protected to reduce any risk in a breach in safety. Data results were downloaded and saved on department servers, which were password protected. Contacts for participants only included email addresses and were stored in Qualtrics as contact books, meaning only the PI and researcher had direct access to the information. All data and contact information were stored on secure departmental servers at Purdue University, in accordance with the IRB guidelines outlined by Purdue University.

## 3.11 Data Analysis

### 3.11.1 Demographic Analysis

In order to describe the participants prior to answering the research questions 1-3, a demographic analysis of the participants was conducted. Demographic information for participants includes age group, gender, state in which they currently teach, and type of area they currently teach in according to the United States Department of Agriculture (USDA). Additionally, participants were asked what their highest degree award was, their primary teaching area, additional teaching areas, and certificates. To preface the research questions, a mean score analysis of demographic information will be presented to inform the results of the study.

### 3.11.2 Problem Solving Inventory (Research Question 1)

To analyze Research Question 1, (What approaches do agricultural and science teachers have towards problem solving?), items from the Problem Solving Inventory were analyzed using sum scores, frequencies of mean scores of each factor, and then combined to get a grand mean for all items. To compare agriculture teachers and science teachers, an ANOVA test was conducted in order to determine if there were group differences as recommended by Bandalos (2018). An ANOVA test is appropriate to determine if there are group differences, and to determine whether or not the null hypothesis should be rejected or accept the alternative hypothesis. The null hypothesis for Research Question 1 stated: there are statistically significant differences between agriculture and science teacher’s responses to the PSI.

There were three factors within the Problem Solving Inventory: problem-solving confidence (PSC), approach-avoidance style (AAS), and personal control (PC). Heppner et al. (1982) stated that low mean scores indicate a higher level of confidence, an approach style and a positive perception of control.  A previous study (Kourmousi et al., 2016) elaborated on the lack of clear directions for analysis and interpretation of scores from the original instrument. Their study used sum scores and indicated that low scores indicated more confidence, more perceived control, and a more approach style while high score indicated low confidence, lack of perceived control, and an avoidance style. As their scale utilized a 5-point Likert scale from “Strongly Agree” as one and “Strongly Disagree” as five, this analysis aligns with low scores being more desirable. Their study attempted to follow Heppner et a. (1982) as closely as possible, but again, there is little direction for interpretation.

For this study, the scale was “never” as one and “always” as five, indicating that higher sum scores are more desirable. Sum scores for problem-solving confidence (PSC) above 33.6 are considered to be more functional at problem-solving. This indicates more confidence when solving problems as participants answered “always” rather than “never”. Lower scores, such as those between 33.5 and 11 indicate lower problem-solving confidence. For approach-avoidance style (AAS), higher scores indicate a more approach style to solving problems, where lower scores indicate a more avoidance style. For personal control (PC) higher scores indicate a more positive perceived sense of control, where lower scores indicate a more negative perceived sense of control. The overall score indicates whether a person perceives themselves as being more or less functional. Again, higher scores would indicate more functional and lower scores would indicate less functional. Figure 3.1 outlines the relationships of the scores to problem-solving functionality.

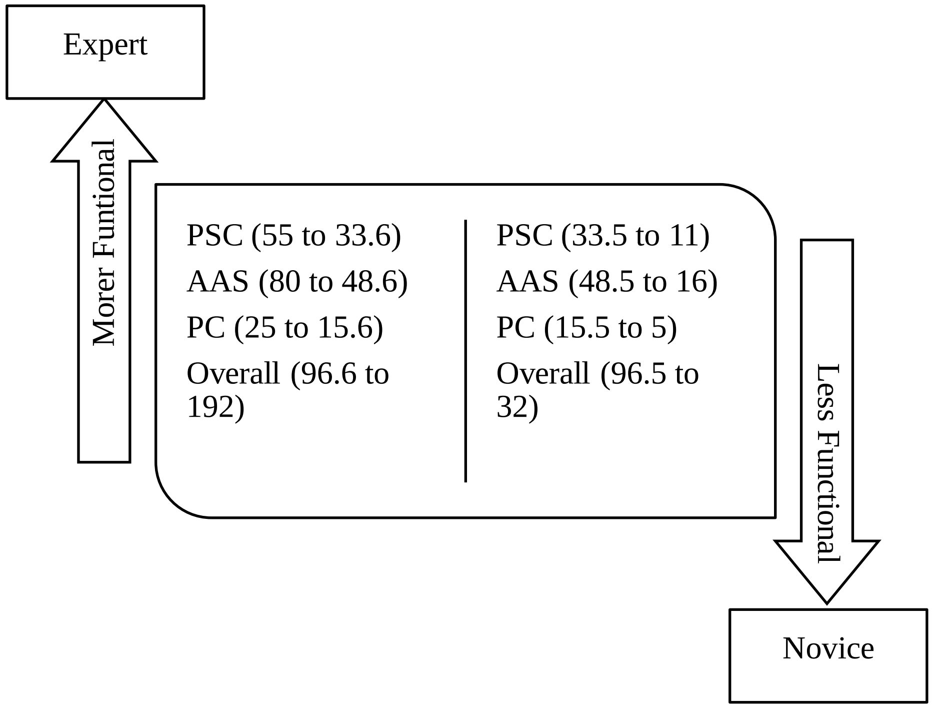


Figure 3.1 Scale of Factors Functionality on the PSI

### 3.11.3 Teaching Science as Inquiry (Research Question 2)

Analysis for Research Question 2 (What level of self-efficacy do agriculture teachers and science teachers hold towards teaching problem solving?) was similar to Research Question 1. As both instruments have multiple factors, mean scores for each factor was analyzed in order to determine self-efficacy beliefs in teaching problem-solving. Similar to the PSI, an ANOVA test was conducted in order to determine group differences between agriculture teacher's and science teacher's self-efficacy and expectancy outcomes in relation to problem-solving. Again, as recommended by Bandalos (2018), testing group differences with an ANOVA test is the most appropriate for this type of study and hypothesis. The null hypothesis for Research Question 2 states: there are statistically significant differences between agriculture teachers' and science teachers' responses to the TSI inventory.

There are two constructs that exist within the Teaching Science as Inquiry instrument: personal self-efficacy (PSE) and expectancy outcomes (EO). Each construct contains questions relating to five essential features: (1) Learner Engages in Scientifically Oriented Questions, (2) Learner Gives Priority to Evidence in Responding Questions, (3) Learner Formulates Explanations from Evidence, (4) Learner Connects Explanations to Scientific Knowledge, and (5) Learner Communicates and Justifies. Mean scores and standard deviations were computed for each construct to determine teacher beliefs. As all questions were written using positive prose, no questions need to be reverse analyzed indicating that analysis of the scores will be similar to the PSI. In order to measure the two constructs, an item score to total test score correlation was completed, as well as an item contribution to total test reliability. This measured the internal validity and reliability of the items to determine mean scores. Table 3.9 highlights the data analysis plan for research questions 1-3.

### 3.11.4 Relationships Between Problem-Solving and Efficacy (Research Question 3)

To answer question three, "What relationships exist between problem-solving approaches (PSC, AAS and PC) and efficacy towards teaching problem-solving (PSE and EO) in agricultural teachers and science teachers?", a Pearson Correlation of the different groups was conducted to determine how the variables from the two tests interact with one another. By taking the mean scores of each factor of questions within the group's science teachers and agriculture teachers, we can see how the problem-solving approaches and efficacy beliefs vary between groups. As there may be false inflation in a Pearson Correlation, there is a need to conduct more tests to determine the true accuracy.

Multiple regressions were also conducted in order to determine what relationships exists between problem-solving factors and teaching efficacy factors. To determine which variables, explain a majority of the variance several multiple regressions were completed. A linear regression is appropriate as teacher self-efficacy is the most explanatory variable. By using problem-solving confidence, approach-avoidance style, personal control, and personal self-efficacy as independent variables, teacher expectancy outcomes can be used as a dependent variable to determine how each factor contributes (Bandalos, 2018; Creswell, 2009). This type of analysis can be completed for both science and agriculture teachers to determine if there are differences between the two. Other independent variables, such as number of years teaching or amount of times problem-based lessons, were also used as independent variables as both contribute to one's self-efficacy. To interpret the results of the linear and multiple regressions, Hopkins (2000) was used which is outlined on Table 3.8.

Table 3.8 *Conventions for Relationships* (Hopkins, 2000)

| **Relationship Coefficient (*r*)** | **Convention** |
|---|---|
| 0.0-0.1 | Trivial |
| 0.1-0.3 | Low |
| 0.3-0.5 | Moderate |
| 0.5-0.7 | High |
| 0.7-0.9 | Very Large |
| 0.9-1.0 | Nearly Perfect |

*Note:* Relationships were reported as positive or negative

Table 3.9 Data Analysis by Research Question

| **Research Question** | **Independent Variables** | **Dependent Variables** | **Scale of Measurement** | **Analysis** |
|---|---|---|---|---|
| RQ1.<br><br>*What approach do agricultural and science teachers have to problem solving?* | | PSC<br><br>AAS<br><br>PC<br><br>PSI_General | Item: Ordinal<br><br>Scale: Interval | *M, SD*<br><br>*ANOVA* |
| RQ2.<br><br>*What level of self-efficacy do agricultural and science teachers hold towards teaching problem solving?* | | PSE<br><br>EO<br><br>TSI General | Item: Ordinal<br><br>Scale: Interval | *M, SD*<br><br>*ANOVA* |
| RQ3.<br><br>*What relationships exist between agricultural and science teacher's problem-solving approach and efficacy towards teaching problem solving?* | PSC<br>AAS<br>PC<br>PSE | EO=<br>PSC*AAS*<br>PC*PSE | Item: Ordinal<br><br>Scale: Interval | *Person's Correlation*<br><br>*Linear and Multiple Regression* |

## 3.12 Chapter Summary

This chapter served the purpose of outlining the participants and instrumentation for this study, as well as an analysis plan for the constructs and factors that exist within. The study surveyed science and agriculture teachers, in 9-12 or high school settings. Participants completed an online Qualtrics survey that was comprised of three sections, the PSI, the TSI, and demographic information. Included in this chapter were descriptions of data collection and data management procedures, as well as IRB protocol numbers and processes. Data were collected completely online and analyzed using SPSS.

# CHAPTER 4. RESULTS

## 4.1 Introduction

This chapter focuses on the results and main findings of this study. Each section is broken down based on the research questions and tests conducted starting with demographic information about the participants.

## 4.2 Purpose of the Study

The purpose of this study was to explore and describe agriculture and science educators' perceived problem-solving approaches, and their self-efficacy towards teaching problem-solving to students influence each other. This study is guided by three research questions with the goal of determining how science and agriculture teachers approach problem-solving, how they differ, and their perceived self-efficacy towards teaching problem-solving.

## 4.3 Research Questions

There were three research questions that guided the study:

1. What approaches do agricultural and science teachers have towards problem-solving?
2. What level of self-efficacy do agriculture teachers and science teachers hold towards teaching problem-solving?
3. What relationships exist between problem-solving approaches (PSC, AAS and PC) and efficacy towards teaching problem-solving (PSE and EO) in agricultural and science teachers?

3a. What percent of variability in the sum of variables (i.e., PSC, AAS, PC, and PSE) are related when regressed towards teacher's expectancy outcomes?

3b. Do the same relationships exist for agriculture and science teachers?

## 4.4 Participant Demographics

There were (N = 504) participants who opened and filled out some portion of the questionnaire. Participants dropped off at various points in the survey, so only those that completed the entire questionnaire were included in the analysis. Following data cleaning, there were a total of (n = 205) participants. A little more than half of the participants were female (59%) with the remainder being male (39.5%) and a small percentage (1.5%) elected not to respond or selected "prefer not to say". In addition to the gender of the participants, table 4.1 outlines the age and number of years teachers, including the current year, have been teaching. The largest population that responded to the survey was between the ages of 44 and 54 (43.1%) and teaching for 21-25 years (19%). Besides years teaching, type of teaching, and age, there are a number of other background factors that may influence their problem-solving that was not accounted for. For example, those that grew up on a farm may have more experiences with problem-solving than those who did not as they encounter a number of problems in the field (Easterly, 2017). Teachers may have also experienced a variety of trainings or professional and personal development events that were not accounted for during this study.

Table 4.1 Demographic overview of participants including sex, age, and number of years teaching ($n$ = 205)

| **Category** | **Response** | **%** | **N** |
|---|---|---|---|
| Sex | | | |
| | Male | 39.5 | 81 |
| | Female | 59.0 | 121 |
| | Prefer not to say | 1.5 | 3 |
| Age | | | |
| | 18-24 | 2.0 | 4 |
| | 25-34 | 14.1 | 29 |
| | 35-44 | 23.4 | 48 |
| | 44-54 | 34.1 | 70 |
| | 55-64 | 22.9 | 47 |
| | 65-74 | 2.4 | 5 |
| | 75+ | 0 | 0 |
| | Prefer not to say | 1.0 | 2 |
| Number of Years Teaching | | | |
| | 1-5 | 10.8 | 22 |
| | 6-10 | 13.2 | 27 |
| | 11-15 | 12.8 | 26 |
| | 16-20 | 16.1 | 33 |
| | 21-25 | 19 | 39 |
| | 26-30 | 12.8 | 26 |
| | 31-35 | 8.3 | 17 |
| | 36-40 | 3 | 6 |
| | 41-45 | 2 | 4 |
| | 45+ | 0 | 0 |
| | Prefer not to say | 2 | 5 |
| Total | | | 205 |

In addition to basic demographic information, participants were also asked what their primary discipline was, what state they currently taught in and what type of area they taught in. Participants were located in Ohio, Indiana, or Iowa. As the survey was only sent to these states there was not a need to include a textbox type or other response. The largest population was from Ohio (43.3%) with Indiana being relatively similar (36.1%) and the fewest were from Iowa (19.5%). Table 4.2 outlines the participants location, as well as their breakdown of discipline and school location. There were n = 9 participants that held science and agriculture certificates and are represented below. The total population pool was still n = 205, but select participants belong to both science and agriculture groups.

Table 4.2 Participant demographics by state, discipline and geographic location (*n* = 205)

| **Category** | **Response** | **%** | **N** |
|---|---|---|---|
| **State** | | | |
| | Indiana | 36.1 | 74 |
| | Iowa | 19.5 | 40 |
| | Ohio | 43.4 | 89 |
| Total | | 100 | 205 |
| **Discipline** | | | |
| | Agriculture | 18.5 | 47 |
| | Agriculture and Science | 4.4* | 9* |
| | Science | 77.1 | 167 |
| Total | | 100 | 205 |
| **School Location** | | | |
| | Rural | 37.6 | 77 |
| | Urban Cluster | 43.3 | 89 |
| | Urban | 18.0 | 37 |
| | No Response | 1.0 | 2 |
| Total | | 100 | 205 |

Participants were also asked what the highest degree they held was, 87% held a master's degree, 19% held a bachelor's, 15% had completed some graduate schooling, and 9% held a Ph.D., Ed.D. or equivalent. Again, two participants did not respond to this question, creating a total population of N = 205. The most common higher degrees held were in education in some form (science, agriculture, environmental, curriculum studies, etc.) or field specific degrees such as botany, wildlife, or geosciences. It should be noted that for the remainder of the research questions, the population decreases by (n = 1) as one participant failed to answer all aspects of the questions and could not be used for the remainder of the study.

## 4.5 Research Question 1

To address Research Question 1 “What approaches do agriculture teachers and science teachers have towards problem-solving?” an analysis of sum scores, mean scores and an ANOVA test was conducted. As sum scores were used for the original test, an analysis of sum scores was used for both groups of teachers to align with an overall idea of their functionality, either less or more. In order for accurate comparisons later with the PSI and ANOVA tests, a mean score was also calculated for each factor of the Problem Solving Inventory (Heppner & Peterson,1982), problem-solving confidence (PSC), approach-avoidance style (AAS), and personal control (PC). A total mean score was also calculated to determine overall problem solving. All scores are based on the participants perceptions and response to items on the Problem Solving Inventory (PSI). Tables 4.3-4.5 outlines sum scores for overall and group participant responses. Tables 4.6-4.8 outlines overall and group mean scores for participant responses to the PSI.

### 4.5.1 Overall Sum Scores for Problem Solving Inventory

As previous studies have analyzed perceived problem-solving functionality using sum scores, the study followed the same analysis approach for consistency with the literature. Table 4.3 outlines sum scores for both science and agriculture teachers combined. As Figure 3.1

interpreted the sum scores and higher scores indicated more functionality, and lower scores, less functionality, analysis will be brief.

Overall sum scores indicate that the teachers, regardless of discipline tended to have a moderate to high sense of problem-solving confidence, have an avoidance approach, and a more negative sense of perceived personal control. As the inventory was about problem-solving in general, it is difficult to determine whether teachers were thinking about problem solving in their teaching, in their personal lives or elsewhere when responding to the inventory. Teachers might be confident when it comes to problem-solving but avoid problem-solving as it causes stress or is too involved, rather than it being difficult. Similar interpretations could be made for the more negative leaning sense of control. Teachers may feel negative emotions as it relates to their home life, select students, faculty or administration, or other reasons not explored. Overall, teachers fall into the category of moderate function, indicating that with the body of knowledge they utilized to respond, they are moderate functioning problem-solvers within it. In order to determine differences between the two groups of teachers, an analysis for each group has been conducted and is shown on tables 4.4 and 4.5.

Table 4.3 Sum Scores for Problem Solving Inventory (*n* = 204)

| Category | Average Sum Score | SD | Min | Max |
|---|---|---|---|---|
| PSC | 40.74 | 2.62 | 33.00 | 47.00 |
| AAS | 47.72 | 3.99 | 36.00 | 64.00 |
| PC | 11.65 | 2.43 | 5.00 | 18.00 |
| Overall | 100.11 | 5.35 | 84.00 | 118.00 |

*Note:* Scores interpretations, PSC: 11-27 (low confidence), 28-38 (moderate confidence) and 39-55 (high confidence), AAS: 16-40 (avoidance), 41-56 (neither approach or avoid), 57-80 (approach), PC: 5-12 (negative feelings of control), 13-18 (moderate feelings of control), 19-25 (positive feelings of control), Overall: 32-80 (less functional), 81-112 (moderate function), 113-160 (more functional)

*4.5.1.1 Agriculture Teacher Sum Scores for Problem Solving Inventory*

Sum scores for agriculture teachers are only slightly higher than total group scores. Agriculture teachers were in the higher ranges for problem-solving confidence, and in the lower ranges for approach-avoidance and perceived personal control. Overall scores were on the higher range indicating a moderate function of problem solving, which aligns with the overall group scores. As the group was smaller than the science teachers, this could be attributed to fewer scores, or other reasons not explored by this research. As this group is not large enough to generalize, it is difficult to determine if the differences can be attributed to discipline.

Table 4.4 Agriculture Teacher's Sum Scores for Problem Solving Inventory (*n* = 47)

| Category | Average Sum Score | SD | Min | Max |
|---|---|---|---|---|
| PSC | 40.57 | 2.83 | 33.00 | 46.00 |
| AAS | 48.15 | 5.03 | 37.00 | 61.00 |
| PC | 12.34 | 2.55 | 7.00 | 18.00 |
| Overall | 101.06 | 6.68 | 84.00 | 118.00 |

*Note:* Scores interpretations, PSC: 11-27 (low confidence), 28-38 (moderate confidence) and 39-55 (high confidence), AAS: 16-40 (avoidance), 41-56 (neither approach or avoid), 57-80 (approach), PC: 5-12 (negative feelings of control), 13-18 (moderate feelings of control), 19-25 (positive feelings of control), Overall: 32-80 (less functional), 81-112 (moderate function), 113-160 (more functional)

*4.5.1.2 Science Teachers Sum Scores for Problem Solving Inventory*

Sum scores for science teachers closely align with overall group sum scores. As science teachers made up more than 80% of the participants, this is to be expected. The results indicate that science teachers are very similar to agriculture teachers in terms of individual factor scores and overall scores on the PSI. The science teachers tended to sometimes be more confident ($M$ = 40.75, $SD$ = 2.55) but had a more avoidance style ($M$ = 47.62, $SD$ = 4.02) and expressed a more negative sense of personal control ($M$ = 11.49, $SD$ = 2.4). Overall, science teachers tended to have moderate functioning in problem solving ($M$ = 100.11, $SD$ = 5.27), which resonates with findings from agriculture teachers and overall sum scores. As mean scores will be used for the remainder of the study, an ANOVA will not be conducted with sum scores to determine group differences.

Table 4.5 Science Teacher's Sum Scores for Problem Solving Inventory (*n* = 167)

| Category | Average Sum Score | SD | Min | Max |
|---|---|---|---|---|
| PSC | 40.75 | 2.55 | 33.00 | 47.00 |
| AAS | 47.62 | 4.02 | 36.00 | 64.00 |
| PC | 11.49 | 2.4 | 5.00 | 18.00 |
| Overall | 100.11 | 5.27 | 84.00 | 118.00 |

*Note:* Scores interpretations, PSC: 11-27 (low confidence), 28-38 (moderate confidence) and 39-55 (high confidence), AAS: 16-40 (avoidance), 41-56 (neither approach or avoid), 57-80 (approach), PC: 5-12 (negative feelings of control), 13-18 (moderate feelings of control), 19-25 (positive feelings of control), Overall: 32-80 (less functional), 81-112 (moderate function), 113-160 (more functional)

### 4.5.2 Overall Means for Problem Solving Inventory

Similar to findings from the sum score analysis of the Problem Solving Inventory, science and agriculture teachers tend to experience moderate function of problem-solving abilities. Teachers again, exhibit high levels of confidence when problem-solving, (*M* = 4.02, *SD* = 0.33), in general. Teachers also had more avoidance style towards problem-solving (*M* = 2.43, *SD* = 0.35) and felt moderate to less positive feelings of control when problem-solving. (*M* = 3.67, *SD* = 0.49). This correlates with the sum scores from section 4.5.1, indicating consistency when analyzing mean scores in favor of overall sum scores as previous studies had. Again, as this inventory was directed towards general problem-solving and not in relation to teaching, or an otherwise specified body of knowledge, it's difficult to determine what teachers thought about when responding to the inventory.

Table 4.6 Mean and Standard Deviations of the Problem Solving Inventory (*n* = 204)

| **Category** | **Mean** | **SD** | **Min** | **Max** |
|---|---|---|---|---|
| PSC | 4.02 | .33 | 3.00 | 4.91 |
| AAS | 2.43 | .35 | 1.50 | 3.31 |
| PC | 3.67 | .49 | 2.40 | 5.00 |
| Overall | 3.26 | .20 | 2.81 | 3.81 |

*Note*: Score interpretation, PSC: 1.0-2.5 (low confidence), 2.6-3.5 (moderate confidence), 3.6-5.0 (high confidence), AAS: 1.0-2.5 (avoidance) 2.6-3.5 (neither avoidance or approach), 3.6-5.0 (approach), PC: 1.0-2.5 (negative feelings of control), 2.6-3.5 (moderate feelings of control), 3.6-5.0 (positive feelings of control), Overall 1.0-2.5 (less functional), 2.6-3.5 (moderate function), 3.6-5.0 (more functional).

*4.5.2.1 Agriculture Teacher Means for Problem Solving Inventory*

Table 4.4 outlines agriculture teachers mean scores for the Problem Solving Inventory. Agriculture teachers reported feeling confident towards problem-solving in general, (*M* = 3.97, *SD* = 0.33), and avoiding problem rather than approaching them (*M* = 2.51, *SD* = 0.35). Agriculture teachers reported feeling moderate feelings of control (*M* = 3.52, *SD* = 0.50), which could be either positive or negative. In this case, neither feeling of positive or negative was strong enough to bend one way or the other. Overall scores (*M* = 3.25, *SD* = 0.20) align with entire group scores, indicating a moderate, or average function of problem solving abilities.

Table 4.7 Mean and Standard Deviations of PSI for Agriculture Teachers (*n* = 47)

| **Category** | **Mean** | **SD** | **Min** | **Max** |
|---|---|---|---|---|
| PSC | 3.97 | 0.36 | 3.0 | 4.64 |
| AAS | 2.51 | 0.36 | 1.81 | 3.19 |
| PC | 3.53 | 0.51 | 2.40 | 4.60 |
| Overall | 3.25 | 0.19 | 2.94 | 3.75 |

*Note*: Score interpretation, PSC: 1.0-2.5 (low confidence), 2.6-3.5 (moderate confidence), 3.6-5.0 (high confidence), AAS: 1.0-2.5 (avoidance) 2.6-3.5 (neither avoidance or approach), 3.6-5.0 (approach), PC: 1.0-2.5 (negative feelings of control), 2.6-3.5 (moderate feelings of control), 3.6-5.0 (positive feelings of control), Overall 1.0-2.5 (less functional), 2.6-3.5 (moderate function), 3.6-5.0 (more functional).

*4.5.2.2 Science Teacher Mean Scores for Problem Solving Inventory*

To compare, a separate table for science teachers was created in order to see differences (Table 4.5). Science teachers were very similar to agriculture teachers, although the group size was nearly three times that of agriculture. Science teachers' indicated feeling confident towards problem-solving (*M* = 4.03, *SD* = 0.32). Similar to agriculture teachers, science teachers exhibited an avoidance style of problem-solving over an approach one and (*M* = 2.41, *SD* = 0.35), and felt neither positive nor negative control towards problem-solving (*M* = 3.70, *SD* = 0.48). Overall science teachers reported having a more moderate, or average function when problem-solving (*M* = 3.27, *SD* = 0.20).

Table 4.8 Mean and Standard Deviations of PSI for Science Teachers (*n* = 167)

| **Category** | **Mean** | **SD** | **Min** | **Max** |
|---|---|---|---|---|
| PSC | 4.03 | 0.32 | 3.00 | 4.91 |
| AAS | 2.41 | 0.35 | 1.50 | 3.31 |
| PC | 3.70 | 0.48 | 2.40 | 5.00 |
| Overall | 3.27 | 0.20 | 2.81 | 3.81 |

*Note*: Score interpretation, PSC: 1.0-2.5 (low confidence), 2.6-3.5 (moderate confidence), 3.6-5.0 (high confidence), AAS: 1.0-2.5 (avoidance) 2.6-3.5 (neither avoidance or approach), 3.6-5.0 (approach), PC: 1.0-2.5 (negative feelings of control), 2.6-3.5 (moderate feelings of control), 3.6-5.0 (positive feelings of control), Overall 1.0-2.5 (less functional), 2.6-3.5 (moderate function), 3.6-5.0 (more functional).

### 4.5.3 ANOVA Test for Agriculture and Science Teachers

To determine if there were true group differences between agriculture and science teachers, and ANOVA test was conducted. An ANOVA test was selected as the choice method of analysis over comparing mean scores as is, as the test adjusts for differences in group sizes. As the population for science teachers was nearly three times that of agriculture teachers, a test that adjusts for this is necessary for accurate analysis.

Based on the results from the ANOVA test (Table 4.6) there were no statistically significant differences between the two groups based on the results from the problem-solving inventory $F(2,203) = .350$, $p = .705$. As the null hypothesis for this study suggested statistically significant group differences between science and agriculture teachers, the null hypothesis for this study would be rejected. After adjusting for group sizes, it can be determined that science and agriculture teachers are indeed similar in terms of how they view problem solving in general.

Table 4.9 ANOVA of Agriculture and Science Teachers PSI (*n* = 204)

| **Factor** | | **Sum of Squares** | **Df** | **Mean Square** | **F** | **Sig.** |
|---|---|---|---|---|---|---|
| **PSC** | Between Groups | 0.31 | 2 | 0.15 | 1.44 | 0.24 |
| | Within Groups | 21.56 | 201 | 0.11 | | |
| | Total | 21.87 | 203 | | | |
| **AAS** | Between Groups | 0.44 | 2 | 0.22 | 1.84 | 0.16 |
| | Within Groups | 23.92 | 201 | 0.12 | | |
| | Total | 24.36 | 203 | | | |
| **PC** | Between Groups | 1.14 | 2 | 0.57 | 2.44 | 0.10 |
| | Within Groups | 46.89 | 201 | 0.23 | | |
| | Total | 48.02 | 203 | | | |
| **Overall** | Between Groups | 0.03 | 2 | 0.01 | 0.35 | 0.71 |
| | Within Groups | 8.04 | 201 | 0.04 | | |
| | Total | 8.07 | 203 | | | |

## 4.6 Research Question 2

Similar to Research Question 1, in order to answer Research Question 2 “What level of self-efficacy do agriculture teachers and science teachers hold towards teaching problem-solving?”, mean scores and an ANOVA test were conducted. The two factors for the Teaching Science as Inquiry, Personal Self-Efficacy (PSE) and Expectancy Outcomes (EO) are reported as mean and standard deviation scores. Table 4.10 reports whole group scores, table 4.11 corresponds to agriculture teacher scores, and table 4.12 corresponds to science teacher scores.

### 4.6.1 Overall Mean Scores for Teaching Science as Inquiry

The Teaching Science as Inquiry inventory is comprised of two major factors, personal self-efficacy and expectancy outcomes. The factors for both inventories are intended to measure a teacher's efficacy towards teaching problem-solving. For the first construct, teachers reported feeling self-efficacious sometimes when teaching problem-solving (*M* = 3.87, *SD* = 0.45). This indicates that most often teachers sometimes had self-efficacious feelings when teaching problem-solving. For the second construct, expectancy outcomes, teachers felt that sometimes they held expectancy outcomes towards problem-solving (*M* = 3.73, *SD* = 0.44). Overall, efficacy toward teaching problem-solving was similar, and teachers sometimes felt officious towards teaching problem-solving (*M* = 3.81, *SD* = 0.43). As the scores were in the upper-ranges of this category, it may suggest that teachers felt they had efficacy towards teaching quite-a-bit but not frequently enough to be considered high efficacy towards teaching problem-solving. Teacher's overall reported feeling they sometimes felt self-efficacious and held certain expectancy outcomes when teaching problem-solving. It should be noted that scores only responses to statements from the TSI and does not reflect overall teaching self-efficacy or expectancy outcomes. There are a number of variables unaccounted for including trainings the participants received, age of the participants, number of years the participants taught, etc. This score only reflects their perceptions of efficacy when teaching problem-solving.

Table 4.10 Group Scores for TSI (*n* = 204)

| Factor | Mean | SD | Min | Max |
|---|---|---|---|---|
| **PSE** | 3.87 | 0.45 | 2.73 | 5.00 |
| **EO** | 3.73 | 0.44 | 2.54 | 4.94 |
| **Overall** | 3.80 | 0.43 | 2.64 | 4.97 |

*Note*: Score interpretation, 1 (never), 2 (seldom), 3 (sometimes), 4 (quite-a-bit), 5 (always)

*4.6.1.1 Agriculture Teachers Mean Scores for Teaching Science as Inquiry*

Agriculture teachers reported similar feelings towards efficacy teaching problem-solving when compared to overall group scores. Reponses in regard to the first construct, personal self-efficacy, agricultural educators reported they sometimes felt self-efficacious teaching problem solving (*M* = 3.79, *SD* = 0.45). Teacher's also reported to sometimes feeling expectancy outcomes when teaching problem solving (*M* = 3.70, *SD* = 0.44). Overall efficacy towards problem-solving aligns with the responses from the two constructs in the inventory. Agriculture teachers indicated sometimes feeling efficacious when teaching problem-solving (*M* = 3.75, *SD* = 0.44). Scores for agriculture teachers were slightly below overall group averages, but still fell within the "sometimes" range.

Table 4.11 Agricultural Education Mean Scores TSI (*n* = 47)

| **Factor** | **Mean** | **SD** | **Min** | **Max** |
|---|---|---|---|---|
| **PSE** | 3.79 | 0.45 | 2.79 | 4.88 |
| **EO** | 3.70 | 0.44 | 2.71 | 4.63 |
| **Overall** | 3.75 | 0.44 | 2.77 | 4.72 |

*Note*: Score interpretation, 1 (never), 2 (seldom), 3 (sometimes), 4 (quite-a-bit), 5 (always)

*4.6.1.2 Science Teachers Mean Scores for Teaching Science as Inquiry*

Science teachers responded similarly to agriculture teachers on the Teaching Science as Inquiry inventory. Science teachers indicated sometimes feeling self-efficacious when teaching problem solving (*M* = 3.90, *SD* = 0.45). In regard to the second construct, science teachers sometimes felt certain expectancy outcomes when teaching problem-solving (*M* = 3.75, *SD* = 0.45). Overall, science teachers felt efficacious sometimes when teaching problem-solving (*M* = 3.83, *SD* = 0.43) echoing agriculture teaches' responses.

Table 4.12 Science Teachers Mean Scores for TSI (*n* = 167)

| **Factor** | **Mean** | **SD** | **Min** | **Max** |
|---|---|---|---|---|
| **PSE** | 3.90 | 0.45 | 2.73 | 5.00 |
| **EO** | 3.75 | 0.45 | 2.54 | 4.94 |
| **Overall** | 3.83 | 0.43 | 2.64 | 4.97 |

*Note*: Score interpretation, 1 (never), 2 (seldom), 3 (sometimes), 4 (quite-a-bit), 5 (always)

### 4.6.2 ANOVA Test for Teaching Science as Inquiry

Table 4.13 outlines ANOVA test scores for science and agriculture teachers scores for the Teaching Science as Inquiry Inventory. Similar to tests conducted for group differences with the Problem Solving Inventory, an ANOVA test was completed to determine if there were differences in regard to the Teaching Science as Inquiry inventory. Based on the results from the ANOVA test, there were no statistically significant differences between agriculture and science teachers sense of efficacy towards teaching problem-solving. As mean scores for both groups were very similar, the results aligned with previous findings. The results of the ANOVA test reject the null hypothesis (there are group differences between science and agriculture teachers) for Research Question 2 as there were no differences between the group's responses.

Table 4.13 ANOVA Test for TSI (*n* = 204)

| **Factor** | | **Sum of Squares** | **df** | **Mean Square** | **F** | **Sig** |
|---|---|---|---|---|---|---|
| **PSE** | Between Groups | 0.92 | 2 | .46 | 2.31 | .10 |
| | Within Groups | 39.99 | 201 | .20 | | |
| | Total | 40.91 | 203 | | | |
| **EO** | Between Groups | 0.20 | 2 | .10 | .50 | .61 |
| | Within Groups | 39.97 | 201 | .20 | | |
| | Total | 40.17 | 203 | | | |
| **Overall** | Between Groups | 0.48 | 2 | .24 | 1.29 | .28 |
| | Within Groups | 37.65 | 201 | .19 | | |
| | Total | 38.13 | 203 | | | |

## 4.7 Research Question 3

To answer Research Question 3 “What relationships exist between problem solving approach (PSC, AAS and PC) and efficacy towards teaching problem-solving (PSE and EO) in agriculture teachers and science teachers?”, a Pearson’s Test for Correlations was conducted to determine relationships that existed. Although there were no group differences between the individual inventories, there are still relationships that exist between the variables of the two inventories. All factors of the inventories were found to have some level of a relationship, several being moderate and high relationships, one being very high, and one being a minor relationship.

Table 4.14 outlines the relationships between the variables from the Problem Solving Inventory (PSC, AAS, and PC) and the Teaching Science as Inquiry Inventory (PSE and EO). Interpretations of the correlational coefficients were interpreted using Hopkins (1997), see section 3.11.1, table 3.8, for more details. The highest correlations that were observed were between expectancy outcomes and personal self-efficacy $r(202) = .875$, $p =<.01$. This indicates that outcome expectancies and personal self-efficacy have a very high and significant relationship with one another at the .01 level. This could suggest that as teachers have an increased sense of personal self-efficacy, their expectancy outcomes will also increase. In this case, their personal self-efficacy and expectancy outcomes towards teaching were related, indicating they function together when teaching problem solving. The relationship is almost to the 0.9 level which Hopkins (1997) indicates as a near perfect relationship.

Table 4.14 Pearson Correlation between factors from PSI and TSI (*n* = 204)

| Factor | | PSC | AAS | PC | PSE | EO |
|---|---|---|---|---|---|---|
| PSC | Pearson Correlation | 1 | | | | |
| | Sig. | - | | | | |
| AAS | Pearson Correlation | .-.351** | 1 | | | |
| | Sig. | .000 | - | | | |
| PC | Pearson Correlation | -.533** | -.327** | 1 | | |
| | Sig. | .000 | .000 | - | | |
| PSE | Pearson Correlation | .461** | -.376** | .308** | 1 | |
| | Sig | .000 | .000 | .000 | - | |
| EO | Pearson Correlation | .355** | -.349** | .207** | .875** | 1 |
| | Sig. | .000 | .000 | .003 | .000 | - |

*Note*: ** correlation is significant at the 0.01 level (2-tailed), * correlation is significant the 0.05 level (2-tailed).

The next strongest correlation was between personal control and problem-solving confidence with a Pearson Correlation value of *r*(202) = 0.533, *p* = <.01. This correlation was also found to be statistically significant at the .01 level. According to Hopkins (1997), this is a high correlation, indicating a strong relationship between the factors personal control and problem-solving. This indicates that personal control and problem-solving have a high, positive relationship with one another when it comes to teaching problem-solving. In addition to one very high and one high positive correlation, there were several moderate relationships.

In total there were seven moderate relationships that ranged from *r*(202) = 0.461, *p* = <.01, on the high end, and *r*(202) = 0.308, *p* = <.01 on the low end. The strongest moderate relationship was observed between personal self-efficacy (PSE) and problem-solving confidence (PSC), with a correlation coefficient of *r*(202) = 0.461, *p* = <.01. This is the highest correlation between the two inventories, suggesting that personal self-efficacy and problem-solving confidence have the strongest relationship. Other moderate relationships in order of strength include: personal self-efficacy (PSE) and approach-avoidance style, *r*(202) = -0.376, problem-solving confidence (PSC) and expectancy outcomes (EO), $r(202) = .355$, problem-solving confidence (PSC) and approach-avoidance style (AAS), PSC & AAS $r(202) = -0.351$, approach-avoidance style (AAS) and expectancy outcomes (EO), $r(202) = -0.349$, approach-avoidance style (AAS) and personal control (PC), $r(202) = -0.327$, and personal control (PC) and personal self-efficacy (PSE), $r(202) = 0.308$. All relationships were found to be significant at the $p = <0.1$ level, indicating relationships between the variables of the two inventories.

Additionally, one relationship was found to be a small, or minor relationship, personal control (PC) and expectancy outcomes (EO), $r(202) = 0.207$. This relationship was found to be statistically significant, but as it is a small or minor correlation, it suggests that is has the lowest relationship between the two inventories. Other variables exhibit stronger relationships, but overall, all variables between the two inventories have some sort of relationship.

## 4.8 Research Question 3a

An extension of Research Question 3, Research Question 3a "What percent of variability in the sum of variables (PSC, AAS, PC, PSE, and Ag vs. Sci) are related when regressed towards teacher's expectancy outcomes", elaborates on the relationships between the PSI and TSI to determine which factors improve or have the strongest relationships over teaching efficacy towards problem-solving. As all of the variables were found to have some level of relationship, a linear and multiple regression was conducted in order to determine if the model was a good fit and which variable account for a majority of the variance. Using expectancy outcomes as the dependent variable, PSE, PSC, PC, AAS and Ag vs. Sci, were used as independent variables. The variable "Ag vs. Sci" was used to determine if discipline is one of the contributing factors to the variance rather than conducting two separate tests. Further analysis in Research Question 3b will analyze whether the results are the same for agriculture and science teachers.

A linear regression of all variables provided a model summary, indicating what amount of the variance was explained. The initial test revealed that 77% of the variance was explained when all variables were included in the model. Further analysis can be seen on table 4.15. The test was found to be significant, so the model is a good fit, but further analysis was conducted in an attempt to capture more of the variance.

Table 4.15 Model Summary of Independent Variables Regressed Towards EO

| Model | R | R Squared | Adjusted R Squared | St. Error of the Estimate | Df1 | Df2 | Sig |
|---|---|---|---|---|---|---|---|
| 1 | .88 | .77 | .77 | .21 | 5 | 198 | .000 |

In addition to a model summary, an ANOVA test was conducted. Based on the results from the ANOVA test for the dependent variable of expectancy outcomes and independent variables of EO, PSE, PSC, PC, AAS and Sci vs. Ag, the model is a good fit. As $R_2 = 0.775$, $F(5,198)$, $p = <0.001$, the model is above 70% and is significant at the $p = 0.01$ level indicating a good fit (Privitera, 2017). This indicates that the factors are a good indicator for overall teaching efficacy towards problem-solving. The results of the ANOVA test are outlined in table 4.16.

Table 4.16 Analysis of the Variance for Overall Self-Efficacy Predictors (n = 204)

| | Sum of Squares | Df | Mean Square | F | Sig |
|---|---|---|---|---|---|
| **Regression** | 31.13 | 5 | 6.23 | 136.45 | .000 |
| **Residual** | 9.04 | 199 | .05 | | |
| **Total** | 40.17 | 203 | | | |

To determine what accounts for the majority of the variance in regard to efficacy teaching problem-solving, the coefficients from the multiple regression test was analyzed. Based on the results of the multiple regression, there was one statistically significant relationship that explained 91% of the variance, $R_2 = 0.899$, $F(5,198) = 23.521$, $p = <.001$. The variable personal self-efficacy was statistically significant at the $p = <0.01$ level and explained a majority of the variance observed.

Although other variables were close, the total variance explained by the model was 77%, $R_2$ = 0.775, $F$(5,198), $p$ = <.001. To determine which variables contributed most to the model and improve the total variance explained, several multiple regressions were conducted. Only the initial regression, and the final regression are presented. Table 4.15 outlines the initial regression with a total variance of 77% with personal self-efficacy accounting for 91% of the variance explained (table 4.17). Table 4.19 outlines the final multiple regression after removing low contributing factors.

Table 4.17 Multiple Regression Coefficients ($n$ = 204)

| Factor | Unstandardized B | Coefficients Std. Error | Standardized Coefficients Beta | t | Sig. |
|---|---|---|---|---|---|
| **Constant** | .29 | .36 | | .82 | .41 |
| **PSC** | .01 | .01 | .040 | .99 | .32 |
| **AAS** | -.003 | .004 | -.025 | -.68 | .49 |
| **PC** | -.01 | .01 | -.044 | -1.11 | .27 |
| **PSE** | .90 | .04 | .91 | 23.52 | .00 |
| **Ag/Sci** | .05 | .03 | .06 | 1.69 | .09 |

After removing multiple low contributing variables, the model that explained the majority of the variance was a two-factor model with personal control and personal self-efficacy. The total variance is almost the same, at 77%, $R_2$ = 0.770, $F$(2,201), $p$ = <0.001 with personal self-efficacy explaining 90%, $R_2$ = 0.899, $F$(2,201) = 25.242, $p$<.001. When other variables were removed in an attempt to explain more of the variance, all models decreased, yet significance of the variables increased. This model attempted to explain the two most significant variables from each of the instruments regressed to expectancy outcomes. Table 4.18 outlines the model summary for the two-factor model, which was found to be significant, indicating it was an appropriate fit.

Table 4.18 Two-Factor Model Summary Regressed Towards EO

| Model | R | R Squared | Adjusted R Squared | St. Error of the Estimate | Df1 | Df2 | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | .88 | .77 | .77 | .21 | 2 | 201 | .000 |

Table 4.19 outlines the variables included in the two-factor model that most accurately explains the relationships and variables within the study. The model is best explained by personal self-efficacy and personal control when regressed towards outcome expectancies. Nearly 90% of the variance was explained by personal self-efficacy when regressed to expectancy outcomes. Although personal control does not contribute nearly as much, nearly all of the variance can be attributed to one variable within the model.

Table 4.19 Multiple Regression Coefficients (*n* = 204)

| Factor | Unstandardized B | Coefficients Std. Error | Standardized Coefficients Beta | t | Sig. |
|---|---|---|---|---|---|
| **Constant** | .53 | 0.15 | | 3.46 | .001 |
| **PC** | -.06 | 0.03 | -0.07 | -1.96 | .05 |
| **PSE** | .90 | 0.04 | .90 | 25.24 | .001 |

## 4.9 Research Question 3b

Research Question 3a examined strength in relationships between the variables of the PSI and TSI. Research Question 3b states "Do the same relationships exist for agriculture teachers and science teachers?" This question can be answered by the results of the multiple regression from Research Question 3a. As the variable "Ag vs. Sci" was found to be insignificant and did not significant attribute to the explanation of the variance, it can be determined that there were no differences between the two groups, and the same relationships exist. As Research Question 1 and Research Question 2 did not find any differences between the two groups, the results from this test aligns with previous findings.

## 4.10 Summary of Findings

The primary findings from Research Questions 1 and 2 suggests there were few differences between agriculture and science teachers. Mean and sum scores for the Problem Solving Inventory suggests few, minor differences between agriculture and science teacher's problem-solving styles. Both agriculture and science teachers were found to have a high level of confidence when problem-solving. In contrast, both science and agriculture teachers were found to have an avoidance-style over an approach-style and felt neither strongly positively nor negatively towards problem-solving. Overall, teachers viewed themselves as being moderately effective problem-solvers. As the inventory only explored how teachers viewed problem-solving in general, it is difficult to determine which body of knowledge teachers were using to support their responses. They could have potentially been thinking about it from a personal standpoint, a professional one, a teaching one, or more. Without asking teachers, it can only be assumed as problem-solving in general as that was how the inventory was written.

The results of the Teaching Science as Inquiry inventory suggested similar findings as the mean scores again, display minute differences between agriculture and science teachers. The mean scores from the personal self-efficacy construct suggested that teachers sometimes felt personally self-efficacious when teaching problem-solving. Results from the second construct also suggest that teachers sometimes felt certain expectancy outcomes when teaching problem-solving. As a result, both agriculture and science teachers sometimes feel efficacious when teaching problem-solving based on their responses to the Teaching Science as Inquiry inventory.

To ensure that differences between group sizes were being accounted for, an ANOVA test was conducted and determined that there were no statistically significant group differences between agriculture teachers and science teachers. Several were close to being statistically significant at the $p$ = <0.1, this could suggest potential group differences if the sample sizes were larger and more robust. Further analysis and interpretation of these results will be discussed in Chapter 5 regarding this finding.

For Research Question 3, the results from the Pearson's correlation determined that there were statistically significant relationships between all variables. The strongest relationships occurred between personal self-efficacy and outcome expectancies, $r(202) = 0.875$, $p = <0.01$. As these variables come from the same instrument, high correlations and relationships were to be expected. As the instrument was modified, this confirms that the instrument measured what was intended, problem-solving teaching efficacy. This correlation is a very high, positive relationship between the two variables. Although this was the only relationship that is a very high, there was one high relationship, seven moderate relationships, and one small or minor relationship.

Personal self-efficacy and problem-solving confidence had moderate correlation of $r(202) = 0.461$, $p = <0.01$, which could suggest the strongest relationships between the two inventories was between these two variables. Several other correlations between the two inventories were moderate relationships, suggesting the two inventories are related and suitable to be used together. All variables were found to be correlated to one another to some degree which is a good indication that problem-solving approaches have a relationship with efficacy teaching problem-solving.

As the two inventories were positively correlated, linear and multiple regression analyses were conducted in order to determine which variables accounted for the majority of the variance. As correlations tend to overinflate relationships between factors, a multiple regression determined more defined relationships. The results from the multiple regression for Research Question 3a indicated that personal self-efficacy and personal control had the strongest relationship with expectancy outcomes. As this was the strongest relationship from the Pearson Correlation test, it can be determined that these relationships are sound, and could suggest they account for a majority of the variance.

As the variable "Ag vs. Sci" was not a strong contributing factor in the multiple regression, it can be determined that there are no differences between agriculture and science teachers. This is supported by Research Questions 1 and 2 as there were no differences when an ANOVA test was conducted for the two surveys. As the ANOVA and multiple regression test adjust for the difference in population size between the two groups, it can be determined that based on the population surveyed, there are no differences between agriculture and science teachers.

# CHAPTER 5. DISCUSSION

## 5.1 Introduction

This chapter focuses on the results and main findings of this study. Each section is broken down based on the research questions and tests conducted starting with demographic information about the participants.

## 5.2 Purpose of the Study

The purpose of this study is to explore and describe agriculture and science educators perceived problem-solving approaches, and their self-efficacy towards teaching problem-solving to students influence each other. This study is guided by three research questions with the goal of determining how science and agriculture teachers approach problem-solving, how they differ, and how their perceived self-efficacy towards teaching problem-solving.

## 5.3 Research Questions

There are three research questions that guide the study that are as follows:

1. What approaches do agriculture teachers and science teachers have towards problem-solving?
2. What level of self-efficacy do agriculture teachers and science teachers hold towards teaching problem solving?
3. What relationships exist between problem-solving approach (PSC, AAS and PC) and efficacy towards teaching-problem solving (PSE and EO) in agricultural and science teachers?

3a. What percent of variability in the sum of variables (i.e., PSC, AAS, PC, and PSE) are related when regressed towards teacher's expectancy outcomes?

3b. Do the same relationships exist for agriculture teachers and science teachers?

## 5.4 Conclusions

There were five major findings associated with this study, each of the findings have been divided into their respective research questions. Research questions 3a and 3b are subheadings within research question 3.

### 5.4.1 Teacher Approach to Problem-Solving

*Conclusion 1: Agriculture teachers and science teachers approached problem-solving in a similar manner. Both felt confident problem-solving quite-a-bit, but only sometimes felt personal control. Teachers also felt a more avoidance style rather than approach when problem solving. Overall, teachers had "moderate functionality" when it came to problem-solving.*

Research Question 1 asked "What approaches do agriculture teachers and science teachers have toward problem-solving?" The study found that both agriculture and science teachers approached problem-solving in a similar manner. Teacher's tended to be confident when problem-solving regardless of discipline. In contrast, both agriculture and science teachers exhibited an avoidance style over an approach style. Teachers also reported feeling neither overtly positive nor negative when it came to solving problems, but were in the middle. When their scores were combined, the results showed that the teachers rated themselves as average problem-solvers, which is interesting as large majority of the teachers were veteran teachers of with 10 or more years of experience (74%). Typically, teachers that have been practicing for 10 or more years are considered to be experts in the field, in other words, a majority of the teachers who responded are experts in their teaching (Norman, 1988).

Teachers regularly engage in problem-solving through with problems presented to them in their teaching. As the survey was in regard to problem-solving in general, it is difficult to determine if teachers answered the questions in regard to problem-solving in teaching or problem-solving in general. We can assume, despite this, that teachers are in fact moderately strong problem-solvers in relation to their level of confidence as it relates to knowledge (Van Merrienboer, 2013). Domain specific knowledge supports problem-solving, leading to problem-solving confidence which showed in their responses to the PSI. Again, as the questionnaire addressed problem-solving in general, it is difficult to determine if teachers answered questions thinking about problem-solving in teaching or problem-solving in general. The domain in which teachers thought about could have been teaching, everyday life, specific domains, etc., but as no prompt was provided, we cannot assume they are confident problem-solvers in their teaching domain. We can assume they are confident and strong problem-solvers in *a* domain, but which domain cannot be determined from their responses on the survey. As the teachers were more confident in problem-solving, this leads to self-efficacy in problem solving (Bandura, 1994). As they are self-efficacious, this could show in their teaching, their everyday life, or elsewhere.

In addition to knowledge, mastery and vicarious experiences (Bandura, 1994) help develop self-efficacy. Bandura's theory supports that there is a relationship between one's self-efficacy and knowledge. The more knowledge or confidence in your knowledge you hold, the most self-efficacious you will be and vice versa. Beyond being a veteran teacher, problem-solving is a part of everyday life (Hambrick et al., 2014), so even those that have been only teaching for a few years may feel more confident in their abilities overall because of the exposure and practice experienced in their undergraduate or secondary education. More than likely teachers have had deliberate practice, or mastery experiences, with both teaching problem-solving, but also problem solving in general, which helps develop expert problem-solvers (Hambrick et al., 2014). This would explain why teachers felt confident in problem-solving, but it does not exactly explain why their approach and feeling of control was being more neutral leaning.

Although teachers demonstrated they are experts in problem-solving in relation to confidence, having an avoidance style and feeling a lack of control are traits that align with being a novice. Avoidance styles relate to lower levels of defining problems and seeking solutions. This finding contradicts the idea that teachers with a high level of efficacy are more experimental and resilient to failures (Tschannen-Moran et al., 1998). It could also be a condition of the current educational structure as standardized testing and teaching a structured curriculum does not provide teachers to be more create and help students problem solve. As an avoidance-style is the result of an inability to overcome setbacks, which relates to novice's and those with a lack of self-efficacy. It is interesting that teachers who are confident in problem-solving, avoid problem-solving, which indicates they could potentially have weak abilities to identify problems or seeking solutions. This could also be the result of improper testing, or a factor that should be further explored. As teachers felt neither negative nor strongly positive towards control it could indicate that teachers do not feel they have control over the problems they are solving which again contradicts confidence in problem-solving. In addition, it could also mean that they jump into solutions or conclusion too quickly or make snap judgements they end up regretting later. Although they feel confident, they can solve the problem, they don't feel control over it.  As this is based on an average score, it is likely that there is some teacher who feel more control and those that feel less, which suggests further testing is necessary to reach a more concise finding. The study given the limited number of participants and openness to interpretations suggest that further testing is necessary for more generalizable results. Despite this there are several claims that can be made from this study regarding how this particular group of teachers' approaches problem-solving.

There have been several other studies that have utilized the PSI in order to determine how people problem solve. For example, several studies have focused on approach-avoidance styles and stress factors or coping mechanisms (Dugar et al., 1995; Finset et al., 2002). They found that people tend to avoid stressful events or be more passive when faced with problems (Finset et al. 2002). Related to this, numerous studies have examined the stress in the American education system and burnout as a result (Farber, 1991; Hayes & Eddy, 1985; Klassen et al., 2010). This could suggest a relationship between the stress a teacher faces in daily life and their approach to problem solving. Teachers may "pick and choose" which tasks they problem solve resulting in a more avoidance style of problem-solving. As the questions on the instrument were regarding general problem-solving, it is difficult to determine whether or not teachers tend to practice the same approach when problem-solving at school versus their daily life away from their job. As these studies utilized teachers, other studies examined other groups and other instruments. For example, Kim & Sin (2007) looked at people's problem-solving skills when applied to sources in a library. The participants in this study were given specific sources to utilize and explain why they selected the sources provided. The study found that participants a high sense of control valued "ease of use" and "familiarity" when selecting sources in problem solving (Kim & Sin, 2007). This means that control could relate to how familiar something is, which could be how familiar the domain in which a problem is to you, or more.

Although assumptions can be made from the survey, there are several limitations from this particular instrument. In order to increase accurate and generalizability, more extensive testing with more participants would need to be conducted. As the instrument did not give participants a prompt as other studies had, it is difficult to determine what teachers were thinking about when taking the inventory. Teachers could have thought about their domain, general problem-solving, or daily life. Although questions were written as daily life, or general problem-solving, we cannot be absolutely sure that every participant interpreted it that way, especially participants also needed to fill out a survey that was specific about teaching problem-solving at the same time. As teachers were provided a short explanation of the study prior to taking the survey, they could have transferred that information as an unintended prompt. In addition to adding a prompt to the survey, a factor analysis should be conducted in order to determine if the factors are loading appropriately with this particular group. As all of the questions related to personal control were worded in terms of someone lacking control, a suitable prompt might have been lacking to elicit responses. As with other sections of the instrument, it is possible that the instrument is not suited for this type of audience due to wording, lack of clarity, or lack of prompts during distribution. Despite understanding from the pilot test, large scale testing with this group may not be suitable as direct contact with the researcher might be necessary.

Overall, participant scores were in the "moderate functionality" of the spectrum indicating that participants were average functioning problem-solvers. As this instrument is a perceived scale, it cannot be determined that participants are, in fact, moderate functioning problem-solvers but rather they perceive themselves this way. As sum scores and mean scores aligned with these results, it can be suggested that teachers from both agriculture and science perceive themselves to be more confident problem-solvers but have a more avoidance style and feel less control. As an ANOVA test was conducted to determine if there were statistically significant differences despite group size variations, there were none to be found.

### 5.4.2 Teacher Self-Efficacy and Expectancy Outcomes

*Conclusion 2: Agriculture teachers and science teachers felt self-efficacious quite-a-bit when teaching problem solving. Both agriculture and science teachers also had quite-a-bit of certain expectancy outcomes when teaching problem-solving. Overall, teachers, regardless of discipline, felt efficacious quite-a-bit when teaching problem-solving.*

Research Question 2 directly relates to teaching practices of problem-solving in terms of personal self-efficacy and expectancy outcomes. Teacher responses on the inventory, regardless of discipline, suggest teachers felt both positive and negative feelings regarding self-efficacy and expectancy outcomes. Despite this, teachers didn't feel more positive or negative, resulting in mean scores right in the middle, or they felt self-efficacious about some items and not others. This could suggest why teachers expressed traits of being both an expert and a novice problem-solver on the PSI. According to Bandura's (1994) model for self-efficacy, a person's self-efficacy influences their behavior. That behavior leads to a particular outcome. In order to produce a certain outcome, a person has certain outcome expectancies that inform said outcome taking into account the behavior and self-efficacy expectation. As self-efficacy is developed through vicarious and mastery experiences, agriculture and science teachers' experiences vary slightly. Agriculture teachers have a higher focus on problem-based learning and teaching where science teachers have a higher focus on inquiry-based learning and teaching. Despite having different training focuses, research shows they don't feel different. Both science and agriculture teachers felt self-efficacious and held high expectancy outcomes towards teaching problem-solving. In science education, NGSS added engineering practices to their guiding practices that reflect both inquiry-based learning and problem-solving. For example, the first practice is "asking questions" which is directed towards science, and "defining problems" which is directed for engineering. Other examples include constructing explanations (science) and designing solutions (engineering). These two practices were modified in order to differentiate between inquiry and problem-solving in the

NGSS (2013) practices. The eight practices are now also called practices in favor of “skills” which was the former term, as both skills and knowledge are being applied, not just field specific skills (NRC Framework, 2012). This suggests that because of the training science teachers receive, they are confident teaching both problem-solving and inquiry as their field has adapted both practices with the introduction of engineering.

Although this instrument appears to be accurately measuring participants and findings are supported by literature, a factor analysis of the constructs should be conducted with this particular group. As the groups for this study were relatively small, and the intent of the study was not to generalize, a factor analysis was not conducted. The original instrument intended to measure pre-service elementary teachers’ efficacy of teaching science (Smolleck, 2008), and few studies have utilized the instrument following development, and most use a pre-post methodology (Lotter et al., 2016). As the instrument was utilized for pre-post studies, and with undergraduate elementary teachers, this could indicate a lack of fit for established middle and highs school science and agriculture teachers. As there is a lack of instruments for measuring problem-solving teaching, modifying existing instruments is the most viable option for a study similar to this one.

Similar to findings for Research Question 1, there were no statistically significant differences found between agriculture and science teachers. This could be explained by the two groups being similar in the sense of age or years taught, but also use of problem-solving in the two subjects. Although the literature states that agriculture more frequently uses problem-solving, and science uses inquiry-based teaching, the teachers survey could be utilizing problem-solving more often than the literature states. Both groups are confident in problem-solving, and also feel efficacious teaching problem-solving. In order to determine this, further testing with more participants would need to be conducted.

### 5.4.3 Relationships Between Problem-Solving Approach and Efficacy

*Conclusion 3: Strong to moderate relationships were found between the PSI and TSI instruments. Self-efficacy and expectancy outcomes have a very strong relationship to one another. All variables shared relationships to some degree, most being strong to moderate relationships. Of these variables, 77% of the variance was explained by personal self-efficacy and personal control.*

Research Question 3 examined relationships between the two surveys to determine if the two tests were suitable to be used together. Based on Bandura's (1997) Social Learning Theory, teachers must be knowledgeable in something if they expect students to learn it. Having an understanding or knowledge of their own problem-solving style, could aid in teacher development for teaching problem-solving. Research Question 3 resulted in a number of claims that could be made based on the results of the study. As the two instruments were found to have multiple moderate correlations, one high correlation, and one very high correlation, it could suggest the ability to utilize the instruments together in future studies. The study found personal self-efficacy has a very strong relationship with expectancy outcomes and is supported by Bandura's Self-Efficacy model (1994). In order to accomplish specific teaching tasks in a particular context (problem-solving) a teacher needs to be self-efficacious and see positive outcomes (Tschannen-Moran et al., 1998). Teacher efficacy can vary by subject (Sarvan & Carkiroglu, 2001), but the study found that regardless of discipline, efficacy and expectancy outcomes are strongly related to one another.

The study also found that problem solving confidence and personal control have a strong relationship. Very strong to moderate relationships between the two instruments exist meaning knowledge of problem-solving is related to self-efficacy teaching problem-solving. As previously stated, confidence and control have a direct relationship with self-efficacy which suggests further testing could reveal even stronger relationships. Personal self-efficacy and problem-problem solving confidence had the strongest relationship between variables from the two inventories. This indicates that problem-solving confidence has the biggest relationship with self-efficacy when teaching problem-solving. This is supported by Bandura (1997) as confidence in one's knowledge and abilities result in stronger self-efficacy and vice versa. Teachers must feel confidence in problem-solving in order to feel self-efficacious when teaching problem-solving.

The remaining correlations, six moderate strength, and one minor correlation indicate the two instruments would be suitable to be used together as they have statistically significant relationships with one another. This could suggest that there is a relationship with how teachers approach problem-solving and how efficacious they feel teaching problem-solving. The limitation of this study rests on the number of participants as there are not nearly enough to generalize about either of the two populations. As a result, the findings of this study can only be related to the population examined but do suggest the need for future studies as there were a number of major claims that can be made.

*5.4.3.1 Research Question 3a*

As multiple regressions were conducted in order to determine predictor values for expectancy outcomes, personal self-efficacy and personal control were the strongest predictor values and explained 77% of the variance. Personal self-efficacy aligns with both Bandura's (1994) model and conceptual framework, and personal control falls within behavior as a person's personal control is their control over behavior and emotions (Heppner & Peterson, 1982). Figure 5.1 represents Bandura's (1997) Self-Efficacy Theory model's cognitive processes. The model incorporates findings from Research Question 3, as both values from the multiple regression fit within the model for self-efficacy that Bandura outlined. Bandura's model outlined the person, behavior and outcome with self-efficacy expectation and outcome expectation as extensions. The model with the incorporated values adds teachers as the person, personal control within behavior, and reinforces self-efficacy and outcome expectations.

As personal control includes both behavior and emotions, the model aims to strengthen the significance personal control as a predicted value for the regression. Although this does not speak to other variables from the PSI as they were not strongly correlated, it does strengthen why personal control is present when a stronger variable like problem-solving confidence is absent. The model follows the regression closely as self-efficacy and personal control significantly regressed towards outcome expectations, which leads to outcomes, in this case teaching problem solving effectively.

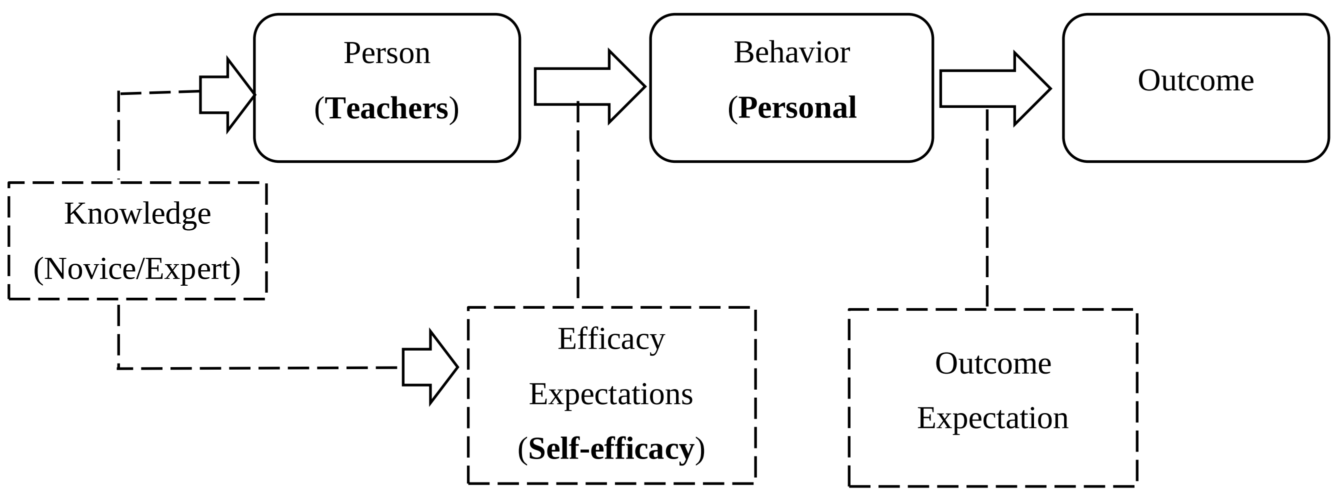


Figure 5.1 Adaptation of Bandura's 1997 Self-Efficacy Model with Regression Outcomes

*5.4.3.2 Research Question 3b*

As similar findings found that there are no differences, it was expected that the two groups shared the same relationships. Again, due to the limited number of participants, more participants could reveal differences between the two groups. Further research regarding the two groups could potentially examine sources of self-efficacy for each group and examples of problem-solving lessons.

## 5.5 Discussion and Limitations

This study had a number of limitations some of which were discussed in the summary of major findings of the research questions. One major limitation of the study was the number and potential bias of the participants. The number of science teachers that responded to the survey were nearly three times that of agriculture teachers that responded. As the instrument was lengthy, teachers that did not have the time were unable to complete the survey. The survey was sent in January, following winter break, which could have been a difficult time for teachers to respond as they are readjusting following time away. During this time agricultural educators are also busy with state award applications and various contest preparations, which potentially hindered participant responses. This could have resulted in a potential bias from those that had the time necessary to complete the survey. Other potential for bias could have come from the study coming from Purdue University so those in Indiana or those who attended Purdue University may have felt more connection to the study and increased response rates.

The type of data collected for this study is another limitation for this study. The study heavily focuses and relies on quantitative data, with little interpretation of qualitative data. Qualitative data has the potential to contextualize answers and offer support to quantitative findings. By including responses of teachers based on their definition of a problem-solving lesson or providing an example would aid in the interpretation and assist in the analysis. The survey also lacked specific demographic information like race or ethnicity which could have provided, and even more insightful view of the data presented.

## 5.6 Implications for Theory and Research

From this study, there are some implications that can be made to theory and research. The results of the Pearson's Correlation and multiple regression indicate relationships between the two inventories. A very high correlation was found between the construct personal self-efficacy and expectancy outcomes from the Teaching Science as Inquiry (Smolleck, 2004) inventory which can be related to Bandura's Self-Efficacy Theory (1997). Relationships between the personal self-efficacy and problem-solving confidence also can be related to Bandura's Self-Efficacy Theory (1997). As the model in Figure 5.1 outlines, knowledge, or in this case problem-solving confidence, has a direct relationship with self-efficacy when teaching problem-solving. This supports further exploration of the use of the PSI and TSI together, supported by Bandura (1997).

The relationships found further supports the importance of self-efficacy and expectancy outcomes on behavior and outcomes. There have been many studies that look at self-efficacy and teaching in both agriculture and science education (Avraamidou, 2014; Ginn & Watters, 1990; Knobloch, 2001; Korte & Simonsen, 2018) yet there is little research on self-efficacy and outcome expectations in agricultural education. It's important to explore these together not only because Bandura's self-efficacy theory emphasizes their connection, but because the found that the two have the strongest relationship. Although we can look at teacher's self-efficacy when teaching using problem-solving, or when teaching about mechanics, it's important to explore if they are seeing positive outcomes for teaching these skills. This opens up a new line of research to explore as there are a number of skills (Easterly et al., 2017; Trilling et al., 2009; Yadav et al., 2016) that teachers in both agriculture and science are expected to teach, but there is little known about whether or not they are experiencing positive outcomes.

### 5.7 Implications for Practice

Teacher professional development and curriculum development were two major areas in which this study was significant to. Based on the findings of this study, teachers struggled with approaching problems and did not have a strong footing in problem-solving confidence. Current teacher professional development events are offered based on teacher interest, preferences, administration preferences or are potentially mandatory trainings. The findings of this study introduce the idea of potentially offering professional development trainings based on cognitive preferences of the teacher. If teachers were given an inventory or survey prior to the professional development, the instruction could be tailored to the teachers' cognitive and personality styles. This could enhance teacher learning and professional development, but also has potential to help develop psychometrics and other educational testing items. Bandura (1994) recommended mastery and vicarious experiences for developing self-efficacy, and a professional development event in which teachers feel they are succeeding and learning from one another increases application of the information learned in said development events.

In addition to teacher professional development events, there is also potential for collaborations among science and agriculture teachers. As the study found few differences between the two groups, successful collaborations could be conducted within these groups. One major area science and agriculture teachers could collaborate in is STEM education and developing 21st century skills as it relies heavily on problem-solving. As both science and agriculture offer numerous topics for integration and collaboration, knowing their thoughts in regard to conducting and teaching problem-solving are similar, helps set the scene for future partnerships. This might not only lead to strong skill development for both teachers and students but has the potential to develop a stronger workforce education and interest in STEM careers.

Secondary students aren't the only students that would greatly benefit from this. Pre-service education is one major area in which mastery and vicarious experiences are beneficial to teachers so implementing support for teaching problem solving throughout pre-service education would be beneficial to students. As students develop through their pre-service programs, they are introduced to various methods to teaching. Often the introduction of these methods is brief or are a part of a more terminal class towards the end of one's educational journey (Hume & Berry, 2011; Myers & Dyers, 2004). In order to help students, develop and hone these skills over time, introducing them earlier in the preservice timeline allows students to utilize them in future courses. As students are often required to conduct micro-teachings for their peers, having the knowledge of teaching techniques and methods like problem-solving allows students to practice them over a longer period of time. The increased time will help students prepare for student teaching and eventually teaching in their own classroom. A study conducted by McLean and Camp (2000) examined the different pre-service courses taught at select universities across the US. The study reported that nine of the ten schools introduced topics of problem-solving and all ten schools incorporated microteachings. Problem-solving was presented as a teaching method, but it does not specifically explore at what stage in pre-service education the idea was being taught. This emphasizes the fact that the idea is not a new one but may need to be adjusted in placement within the curriculum in order to help students develop the skills over time.

To better support teacher collaborations, curriculum could be developed focusing on problem-solving in STEM, science, and agriculture. As recent developments in curriculum and standard changes such as the addition of problem-solving to the Next Generation Science standards (2013) and the emphasis of science in the Curriculum for Agricultural Science Education (2010), there is a need and interest for curricular support. Further exploration and a more generalizable study are recommended prior to the creation of curricular supports as more qualitative data should be considered.

## 5.8 Recommendations

Recommendations for methodology focus around participants and survey distribution methods. As this study was conducted using only three states and a very limited number of participants (n = 205), this study could be replicated in the future to provide a more in-depth analysis and perhaps even generalize about science and agriculture teachers. As more states are surveyed, more detailed information could be determined from the studies.

The survey was sent out over three weeks, and one reminder email was sent out. As there was a slight increase in responses following the reminder email, response rates were still low. Science teachers accounted for a majority of the respondents which could be explained by a larger number of participants surveyed. Future recreations should be aware of other surveys being distributed to agriculture teachers as they are a smaller group, receive surveys frequently. To prevent survey fatigue, being aware of other surveys could increase response rates.

### 5.8.1 Methodology

Recommendations following this study can be divided into two major categories, methodology and instrumentation. As this study was conducted via an internet survey and distributed to a niche group of teachers, there are certain limitations and findings that can be addressed in regard to future research. This study also utilized two instruments, the PSI has not been used in science or agriculture, and TSI has not been used in agriculture. As the Teaching Science as Inquiry instrument was modified for the study, the instrument has not been used in this group and has potential for future studies. Future recommendations relate to both future testing of agriculture and science groups and instrumentation used in the study.

### 5.8.2 Instrumentation

Recommendations for instrumentation regard modifications that could be made to potentially increase accuracy and response rates. As the Problem Solving Inventory has not been used for science and agriculture teachers, further testing should include more participants. More participants would not only provide more accurate, generalizable information about the groups, confirmatory factor analysis could be conducted to determine if factors are correctly loading for each factor. As there more moderate than strong correlations between the two instruments, this could either suggest the factors are not loading correctly or there are no relationships that exist. Further testing could inform future studies and the use of the instrument with science and agricultural audiences.

As the Teaching Science as Inquiry Instrument was modified, further testing could reveal that the instrument could be used for other groups beyond science and agriculture, or other topics. As the instrument is very long (69 questions), a confirmatory analysis should be conducted in order to reduce the number of questions in the survey.

One major issue with the current study was participant responses. The survey contained over 90 questions, as the PSI is 32 questions and the TSI is 69 questions long. Participants tended to open the survey, view the first set of questions and close out of the survey. This could have been the result of the format of the questions, or the length of the instrument, or perhaps even interest. Demographic information was at the end of the survey which followed Dillman's (2005) recommendations. This may not have been the best choice for this survey as it was difficult to track participants if they only partially filled out the survey. For example, if participants filled out the first instrument and the second instrument, but did not move on to the demographic information, their response could not be used as there was no way to determine which group it belonged to. If demographic information was at the beginning or separate surveys were sent to science and agriculture teaching, participants could more easily be tracked without knowing identity.

As testing and validating instruments is a continual process, this instrument is no different. In order to use it with more audiences, more testing will need to be conducted in order to determine the true range of the instrument. Again, this could lead to elimination of questions because of multicollinearity or inappropriate loading of factors.

## 5.9 Future Research

Future studies should capture applied problem-solving abilities of teachers through classroom observations or simulations. As the instrument was oriented towards measuring general problem-solving abilities and perceived self-efficacy towards teaching problem-solving, observing these skills could portray teachers more accurately. Through classroom observations, and more extensive studies, generalizability could be achieved. Studies that involve classroom observations should also include interviews, as teachers would be able to elaborate on their problem-solving process, which would inform how teachers approach problem solving in teaching. In addition to classroom observations, more qualitative data such as interviews or focus groups should be conducted to add richness to the data. Studies should include both novice, early career, expert, and late career teachers to determine if age or number of years teaching make a difference in their efficacy or problem-solving approach and abilities. This same idea could be done through a survey, but focus groups or interview are recommended to support responses.

Future studies should also extend the teachers and examine student's problem-solving. As problem-solving is a vital 21st Century skill, knowing whether or not teachers are effectively aiding in the development is necessary. Although studies would not suggest whether one teacher is directly influencing their problem-solving development overall, pre and post studies could be conducted to determine teacher influence on problem-solving ability. This could lead to interventions or aid in pre-service and in-service teacher professional development. A study conducted by Easterly et al. (2017) explored the skills desired by agriculture and natural resource industry leaders. Critical thinking was the top skill cited by agricultural leaders, where problem-solving was one of the top three skills cited by natural resource leaders. Industries seek out students and individuals that have these qualities and skills so developing them in secondary and post-secondary settings is vital for the workforce.

One issue with the current study that future recreations should consider is the methodology of the study. The survey itself was long and lacked prompting to participants. By conducting a confirmatory-factor analysis, the survey could potentially be reduced to ask only pertinent questions relating to the desired results. As the study was not intended to generalize, future studies should focus on recruiting more teachers in order to potentially work towards generalizability. With generalizable results, changes to pre-service and continuing in-service education would be more supported.

## 5.10 Summary

Despite few differences being found between science and agriculture teachers, there are still valuable findings from this study. Teachers tended to have a high sense of confidence when problem-solving, which is highly valued in teaching and STEM areas. As teachers did have average scores overall on the PSI inventory, this indicates that overall teachers are moderately skilled problem solvers. The results of the TSI inventory found that teachers overall feel self-efficacious and have strong expectancy outcomes when teaching problem-solving, which again, is highly valued to STEM, agriculture and natural resource fields. Although science and agriculture teachers were not different, it does support that these two fields are appropriate for integrating STEM related challenges, such as solving "wicked problems" or conducting real-world challenges.

Further developments of the PSI and TSI could potentially result in stronger correlations and relationships to be utilized by more areas beyond science, agriculture, and preservice elementary teachers. Although there were a number of moderate and high correlations, by conducting confirmatory factor analyses or testing's on larger groups, more correlations could reach the high or very high range. This has the potential to explain more of the variance, creating a more theoretically and conceptually sound instrument. As the test is lengthy future reiterations should attempt to reduce the number of questions to increase participant responses and reduce survey fatigue. Distributing the survey to more participants in a variety of states could support generalizability and create more solid conclusions regarding the two groups. Overall, the literature supports the need for instruments to further explore related ideas in science and agriculture.

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# APPENDIX A. IRB APPROVAL

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IRB-2019-901 - Initial: Initial Submission - Exempt

irb@purdue.edu
Mon 1/13/2020 10:52 AM
Wang, Hui-Hui; Bryanna J Nelson

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**Date:** January 13, 2020
**PI:** HUI-HUI WANG
**Department:** PWL YOUTH DEVL AG EDUC
**Re:** Initial - IRB-2019-901
*Agriculture and Science Teachers Problem Solving Approaches and Relation to Teaching Efficacy*

The Purdue University Human Research Protection Program (HRPP) has determined that the research project identified above qualifies as exempt from IRB review, under federal human subjects research regulations 45 CFR 46.104. The Category for this Exemption is listed below . Protocols exempted by the Purdue HRPP do not require regular renewal. However, the administrative check-in date is **January 13, 2023**. The IRB must be notified when this study is closed. If a study closure request has not been initiated by this date, the HRPP will request study status update for the record.

Specific notes related to your study are found below.
**Decision:** Exempt
**Category:** Category 2.(i). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording).
The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects.

**Findings:**
**Research Notes:**

Any modifications to the approved study must be submitted for review through Cayuse IRB. All approval letters and study documents are located within the Study Details in Cayuse IRB.

**What are your responsibilities now, as you move forward with your research?**

Reply all | Delete Junk Block ···

IRB-2019-901 - Initial: Initial Submission - Exempt

**What are your responsibilities now, as you move forward with your research?**

**Document Retention:** The PI is responsible for keeping all regulated documents, including IRB correspondence such as this letter, approved study documents, and signed consent forms for at least three (3) years following protocol closure for audit purposes. Documents regulated by HIPAA, such as Release Authorizations, must be maintained for six (6) years.

**Site Permission:** If your research is conducted at locations outside of Purdue University (such as schools, hospitals, or businesses), you must obtain written permission from all sites to recruit, consent, study, or observe participants. Generally, such permission comes in the form of a letter from the school superintendent, director, or manager. You must maintain a copy of this permission with study records.

**Training:** All researchers collecting or analyzing data from this study must renew training in human subjects research via the CITI Program ( www.citiprogram.org) every 4 years. New personnel must complete training and be added to the protocol before beginning research with human participants or their data.

**Modifications:** Change to any aspect of this protocol or research personnel must be approved by the IRB before implementation, except when necessary to eliminate apparent immediate hazards to subjects or others. In such situations, the IRB should still be notified immediately.

**Unanticipated Problems/Adverse Events:** Unanticipated problems involving risks to subjects or others, serious adverse events, and
noncompliance with the approved protocol must be reported to the IRB immediately through an incident report. When in doubt, consult with the HRPP/IRB.

**Monitoring:** The HRPP reminds researchers that this study is subject to monitoring at any time by Purdue's HRPP staff, Institutional Review Board, Research Quality Assurance unit, or authorized external entities. Timely cooperation with monitoring procedures is an expectation of IRB approval.

**Change of Institutions:** If the PI leaves Purdue, the study must be closed or the PI must be replaced on the study or transferred to a new IRB. Studies without a Purdue University PI will be closed.

**Other Approvals:** This Purdue IRB approval covers only regulations related to human subjects research protections (e.g. 45 CFR 46). This determination does not constitute approval from any other Purdue campus departments, research sites, or outside agencies. The Principal Investigator and all researchers are required to affirm that the research meets all applicable local, state, and federal laws that may apply.

If you have questions about this determination or your responsibilities when conducting human subjects research on this project or any other, please do not hesitate to contact Purdue's HRPP at irb@purdue.edu or 765-494-5942. We are here to help!

# APPENDIX B. LETTER TO PARTICIPANTS

Greetings!

My name is Bryanna Nelson, a graduate student at Purdue University in the Agricultural Sciences Education and Communication department. I am currently in the process of completing my thesis research for my master's degree. As part of the process, I am interested in surveying science and agricultural educators regarding their approach to problem-solving, and how problem-solving is being taught. As science and agriculture teachers use this approach frequently, your expertise on the topic is highly valued for this study.

If you choose to participate in this survey, all information will be confidential and password-protected and should take you roughly 8-10 minutes to complete. You will find the link to the survey at the bottom of this email, which will take you to the Qualtrics portal to complete.

If you have any questions regarding the survey, purpose or any other question you might have, you may contact me, or my advisor/PI, Dr. Hui-Hui Wang. This information will also be included at the bottom of this email.

This study is IRB approved (**IRB-2019-901)** and is titled Agriculture and Science Teachers Problem Solving Approaches and Relation to Teaching Efficacy.

I thank you for taking the time to read this email, and appreciate your participation, should you choose to!
Best,
Bryanna Nelson
Nelso421@purdue.edu
651-500-8961

Hui-Hui Wang
Huiwang@purdue.edu

**Follow this link to the Survey:**
${l://SurveyLink?d=Take the Survey}

Or copy and paste the URL below into your internet browser:
${l://SurveyURL}

Follow the link to opt out of future emails:
${l://OptOutLink?d=Click here to unsubscribe}

# APPENDIX C. ORIGINAL TSI INSTRUMENT

**Appendix N**

**Self-Efficacy Beliefs in Regard to Teaching of Science as Inquiry - Final**

Student Number: ________________________ Circle One: Male Female

Section Number: ______________________

Please indicate the degree to which you agree or disagree with each statement below by circling in the appropriate number as indicated below.

| | | |
|---|---|---|
| 5 | = | Strongly Agree |
| 4 | = | Agree |
| 3 | = | Uncertain |
| 2 | = | Disagree |
| 1 | = | Strongly Disagree |

| **When I teach science…** | **Strongly Agree** | | | | **Strongly Disagree** |
|---|---|---|---|---|---|
| 1. I will be able to offer multiple suggestions for creating explanations from data. | 5 | 4 | 3 | 2 | 1 |
| 2. I will be able to provide students with the opportunity to construct alternative explanations for the same observations. | 5 | 4 | 3 | 2 | 1 |
| 3. I will be able to encourage my students to independently examine resources in an attempt to connect their explanations to scientific knowledge. | 5 | 4 | 3 | 2 | 1 |
| 4. I possess the ability to provide meaningful common experiences from which predictable scientific questions are posed by students. | 5 | 4 | 3 | 2 | 1 |
| 5. I have the necessary skills to determine the best manner through which children can obtain scientific evidence. | 5 | 4 | 3 | 2 | 1 |
| 6. I will require students to defend their newly acquired knowledge during large and/or small group discussions. | 5 | 4 | 3 | 2 | 1 |
| 7. My students will select among a list of given questions while investigating scientific phenomena. | 5 | 4 | 3 | 2 | 1 |

| When I teach science… | Strongly Agree | | | | Strongly Disagree |
|---|---|---|---|---|---|
| 8. I will provide opportunities through which children will obtain evidence from observations and measurements. | 5 | 4 | 3 | 2 | 1 |
| 9. I will expect my students to make the results of their investigations public. | 5 | 4 | 3 | 2 | 1 |
| 10. I will be able to provide opportunities for students to become the critical decision makers when evaluating the validity of scientific explanations. | 5 | 4 | 3 | 2 | 1 |
| 11. I will be able to guide students in asking scientific questions that are meaningful. | 5 | 4 | 3 | 2 | 1 |
| 12. I will be able to provide opportunities for my students to describe their investigations and findings to others using their evidence to justify explanations and how data was collected. | 5 | 4 | 3 | 2 | 1 |
| 13. I will create (plan) investigations through which students will be expected to gather particular evidence. | 5 | 4 | 3 | 2 | 1 |
| 14. I will be able to negotiate with students possible connections between/among explanations. | 5 | 4 | 3 | 2 | 1 |
| 15. I will expect students to independently develop explanations using what they already know about scientifically accepted ideas. | 5 | 4 | 3 | 2 | 1 |
| 16. I encompass the ability to encourage students to review and ask questions about the results of other students' work. | 5 | 4 | 3 | 2 | 1 |
| 17. I will be able to guide students toward appropriate investigations depending on the questions they are attempting to answer. | 5 | 4 | 3 | 2 | 1 |
| 18. I will be able to create the majority of the scientific questions needed for students to investigate. | 5 | 4 | 3 | 2 | 1 |
| 19. I possess the ability to allow students to devise their own problems to investigate. | 5 | 4 | 3 | 2 | 1 |

| When I teach science… | Strongly Agree | | | | Strongly Disagree |
|---|---|---|---|---|---|
| 20. My students will make use of data in order to develop explanations as a result of teacher guidance. | 5 | 4 | 3 | 2 | 1 |
| 21. I will be able to play the primary role in guiding the identification of scientific questions. | 5 | 4 | 3 | 2 | 1 |
| 22. I will be able to guide students toward scientifically accepted ideas upon which they can develop more meaningful understandings of science. | 5 | 4 | 3 | 2 | 1 |
| 23. I possess the abilities necessary to provide students with the possible connections between scientific knowledge and their explanations. | 5 | 4 | 3 | 2 | 1 |
| 24. I will expect students to recognize the connections existing between proposed explanations and scientific knowledge. | 5 | 4 | 3 | 2 | 1 |
| 25. I will expect students to ask scientific questions. | 5 | 4 | 3 | 2 | 1 |
| 26. I possess the skills necessary for guiding my students toward explanations that are consistent with experimental and observational evidence. | 5 | 4 | 3 | 2 | 1 |
| 27. My students will investigate questions I have developed. | 5 | 4 | 3 | 2 | 1 |
| 28. My students will create scientific explanations based on evidence, as a result of teacher assistance. | 5 | 4 | 3 | 2 | 1 |
| 29. My students will derive scientific evidence from instructional materials such as a textbook. | 5 | 4 | 3 | 2 | 1 |
| 30. I will be able to encourage students to gather the appropriate data necessary for answering their questions. | 5 | 4 | 3 | 2 | 1 |
| 31. I will be able to offer/model approaches for generating explanations from evidence. | 5 | 4 | 3 | 2 | 1 |
| 32. I will be able to coach students in the clear articulation of explanations. | 5 | 4 | 3 | 2 | 1 |

| When I teach science… | Strongly Agree | | | | Strongly Disagree |
|---|---|---|---|---|---|
| 33. Through the process of sharing explanations, I will be able to provide students with the opportunity to critique explanations and investigation methods. | 5 | 4 | 3 | 2 | 1 |
| 34. I will require students to create scientific claims based on observational evidence. | 5 | 4 | 3 | 2 | 1 |
| 35. I will expect my students to think about otherreasonable explanations that can be derived from the evidence presented. | 5 | 4 | 3 | 2 | 1 |
| 36. I will be able to facilitate open-ended, long-term student investigations in an attempt to provide opportunities for students to gather evidence. | 5 | 4 | 3 | 2 | 1 |
| 37. I will be able to help students refine questions posed by the teacher or instructional materials, so they can experience both interesting and productive investigations. | 5 | 4 | 3 | 2 | 1 |
| 38. I will be able to provide demonstrations through which students can focus their queries into manageable questions for investigation. | 5 | 4 | 3 | 2 | 1 |
| 39. I will require students to develop explanations using evidence. | 5 | 4 | 3 | 2 | 1 |
| 40. I will be able to utilize worksheets as an instructional tool for providing a data set and walking students through the analysis process. | 5 | 4 | 3 | 2 | 1 |
| 41. My students will refine their explanations using possible connections to scientific knowledge that have been provided. | 5 | 4 | 3 | 2 | 1 |
| 42. I will be able to model for my students prescribed steps or procedures for communicating scientific results to the class. | 5 | 4 | 3 | 2 | 1 |
| 43. I will be able to provide my students with possible connections to scientific knowledge through which they can relate their explanations. | 5 | 4 | 3 | 2 | 1 |
| 44. I will be able to provide my students with evidence to be analyzed. | 5 | 4 | 3 | 2 | 1 |

| When I teach science… | Strongly Agree | | | | Strongly Disagree |
|---|---|---|---|---|---|
| 45. My students will engage in questions I have provided them. | 5 | 4 | 3 | 2 | 1 |
| 46. My students will engage in questions that are provided by a variety of sources such as the textbook. | 5 | 4 | 3 | 2 | 1 |
| 47. My students will analyze data that has been supplied, while following teacher instruction. | 5 | 4 | 3 | 2 | 1 |
| 48. I will expect my students to clarify the questions provided in an attempt to enhance science learning. | 5 | 4 | 3 | 2 | 1 |
| 49. I will be able to provide my students with the data needed to support an investigation. | 5 | 4 | 3 | 2 | 1 |
| 50. My students will communicate and justify their explanations to the class using broad guidelines that have been provided. | 5 | 4 | 3 | 2 | 1 |
| 51. My students will choose the questions they would like to investigate from a list provided. | 5 | 4 | 3 | 2 | 1 |
| 52. My students will analyze teacher provided data in a particular manner. | 5 | 4 | 3 | 2 | 1 |
| 53. My students will form their explanations using evidence that has been provided. | 5 | 4 | 3 | 2 | 1 |
| 54. I will be able to provide my students with all evidence required to form explanations through the use of lecture and textbook readings. | 5 | 4 | 3 | 2 | 1 |
| 55. My students will construct explanations from evidence using a framework I have provided. | 5 | 4 | 3 | 2 | 1 |
| 56. I will expect my students to follow predetermined procedures when justifying their explanations. | 5 | 4 | 3 | 2 | 1 |
| 57. My students will determine what evidence will be most useful for answering their scientific question(s). | 5 | 4 | 3 | 2 | 1 |
| 58. My students will design their own investigations and gather the evidence necessary to answer a particular question. | 5 | 4 | 3 | 2 | 1 |

| When I teach science… | Strongly Agree | | | | Strongly Disagree |
|---|---|---|---|---|---|
| 59. I will expect my students to collaborate with me in an attempt to construct criteria for sharing and critiquing explanations. | 5 | 4 | 3 | 2 | 1 |
| 60. My students will share and critique explanations while utilizing broad guidelines that have been provided. | 5 | 4 | 3 | 2 | 1 |
| 61. I will expect students to use internet based resources or other materials to further develop their investigations. | 5 | 4 | 3 | 2 | 1 |
| 62. I will be able to model for my students the guidelines to be followed when sharing and critiquing explanations. | 5 | 4 | 3 | 2 | 1 |
| 63. I will be able to instruct students to independently evaluate the consistency between their own explanations and scientifically accepted ideas. | 5 | 4 | 3 | 2 | 1 |
| 64. I will expect my students to negotiate with me the criteria for sharing and critiquing explanations. | 5 | 4 | 3 | 2 | 1 |
| 65. I will be able construct with students the guidelines for communicating results and explanations. | 5 | 4 | 3 | 2 | 1 |
| 66. I will expect my students to refine questions that have been provided. | 5 | 4 | 3 | 2 | 1 |
| 67. I will be able to provide my students with explanations. | 5 | 4 | 3 | 2 | 1 |
| 68. I will expect my students to justify explanations using given steps and procedures. | 5 | 4 | 3 | 2 | 1 |
| 69. My students will comprehend teacher presented explanations. | 5 | 4 | 3 | 2 | 1 |

# APPENDIX D. QUESTIONNAIRE



**Problem Solving Inventory**

Hello, my name is Bryanna Nelson and I am a graduate student at Purdue University.

Thank you for choosing to participate in this survey. The survey is estimated to take around 15 minutes, but most participants from the pilot testing took around 8-10 minutes. You are able to leave the survey and come back and continue where you left off. The survey is divided into three major blocks, the first will ask about your problem solving approaches, the second will ask about your self-efficacy teaching problem solving, and the third and final section is basic demographic information. All responses collected are anonymous, confidential and password protected. You do not need to provide any sensitive information to participate.

The survey may feel repetitive due to the look and nature of the questions. To track your progress, you can find a progress bar at the top of the survey.

The purpose of this study is to learn more about agriculture and science teachers problem solving approaches and self-efficacy teaching problem solving. This study will help fulfill requirements for a thesis in the Master's degree program at Purdue University in the Agricultural Sciences Education and Communication department.

This survey is IRB approved, and has the ID number IRB-2019-901 if you IRB related questions.

If you have any other questions, please feel free to contact either myself, Bryanna Nelson, or my adviser Dr. Hui-Hui Wang.

Bryanna Nelson
Nelso421@purdue.edu
6515008961

Dr. Hui-Hui Wang
huiwang@purdue.edu

Please respond to the following statements with the choice that fits best.

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| I am usually able to think up creative and effective alternatives to solve a problem. | ○ | ○ | ○ | ○ | ○ |
| I have the ability to solve most problems even though initially no solution is immediately apparent. | ○ | ○ | ○ | ○ | ○ |
| Many problems I face are too complex for me to solve. | ○ | ○ | ○ | ○ | ○ |
| I make decisions and am happy with them later. | ○ | ○ | ○ | ○ | ○ |
| When I make plans to solve a problem, I am almost certain that I can make them work. | ○ | ○ | ○ | ○ | ○ |

Please respond to the following statements with the choice that fits best.

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| Given enough time and effort, I believe I can solve most problems that confront me. | ○ | ○ | ○ | ○ | ○ |
| When faced with a novel situation I have confidence that I can handle problems that may arise. | ○ | ○ | ○ | ○ | ○ |

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| I trust my ability to solve new and difficult problems. | ○ | ○ | ○ | ○ | ○ |
| After making a decision, the outcome I expected usually matches the actual outcome. | ○ | ○ | ○ | ○ | ○ |
| When confronted with a problem, I am unsure of whether I can handle the situation. | ○ | ○ | ○ | ○ | ○ |
| When I become aware of a problem, one of the first things I do is to try to find out exactly what the problem is. | ○ | ○ | ○ | ○ | ○ |

Please respond to the following statements with the choice that fits best.

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| When a solution to a problem was unsuccessful, I do not examine why it didn't work. | ○ | ○ | ○ | ○ | ○ |
| When I am confronted with a complex problem, I do not bother to develop a strategy to collect information so I can define exactly what the problem is. | ○ | ○ | ○ | ○ | ○ |
| After I have solved a problem, I do not analyze what went right or what went wrong. | ○ | ○ | ○ | ○ | ○ |

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| After I have tried to solve a problem with a certain course of action, I take time and compare the actual outcome to what I thought should have happened. | ○ | ○ | ○ | ○ | ○ |
| When I have a problem, I think up as many possible ways to handle it as I can until I can't come up with any more ideas. | ○ | ○ | ○ | ○ | ○ |

Please respond to the following statements with the choice that fits best.

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| When confronted with a problem, I consistently examine my feelings to find out what is going on in a problem situation. | ○ | ○ | ○ | ○ | ○ |
| When confronted with a problem, I tend to do the first thing that I can think of to solve it. | ○ | ○ | ○ | ○ | ○ |
| When deciding on an idea or possible solution to a problem, I do not take time to consider the chances of each alternative being successful. | ○ | ○ | ○ | ○ | ○ |
| When confronted with a problem, I stop and think about it before deciding on a next step. | ○ | ○ | ○ | ○ | ○ |
| I generally go with the first good idea that comes to my mind. | ○ | ○ | ○ | ○ | ○ |

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| When making a decision, I weigh the consequences of each alternative and compare them against each other. | ◯ | ◯ | ◯ | ◯ | ◯ |

Please respond to the following statements with the choice that fits best.

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| I try to predict the overall result of carrying out a particular course of action. | ◯ | ◯ | ◯ | ◯ | ◯ |
| When I try to think up possible solutions to a problem, I do not come up with very many alternatives. | ◯ | ◯ | ◯ | ◯ | ◯ |
| I have a systematic method for comparing alternatives and making decisions | ◯ | ◯ | ◯ | ◯ | ◯ |
| When confronted with a problem, I do not usually examine what sort of external things my environment may be contributing to my problem. | ◯ | ◯ | ◯ | ◯ | ◯ |
| When I am confused by a problem, one of the first things I do is survey the situation and consider all the relevant pieces of information. | ◯ | ◯ | ◯ | ◯ | ◯ |

Please respond to the following statements with the choice that fits best.

| Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| When my first efforts to solve a problem fail, I become uneasy about my ability to handle the situation. | ○ | ○ | ○ | ○ | ○ |
| Sometimes I do not stop and take time to deal with my problems, but just kind of muddle ahead. | ○ | ○ | ○ | ○ | ○ |
| Even though I work on a problem, sometimes I feel like I am groping or wandering, and am not getting down to the real issue. | ○ | ○ | ○ | ○ | ○ |
| I make snap judgments and later regret them. | ○ | ○ | ○ | ○ | ○ |
| Sometimes I get so charged up emotionally that I am unable to consider many ways of dealing with my problems. | ○ | ○ | ○ | ○ | ○ |

**Definition of Problem Solving**

For the following questions, consider problem-solving as a task for which students are engaging in learning through problems.

Problem-solving is the act of defining a problem; determining the cause of the problem; identifying, prioritizing and selecting alternatives for a solution; and implementing a solution.
Problem-solving is a process of ongoing activity in which we take what we know to discover what we don't know. It involves overcoming obstacles by generating hypotheses, testing those predictions, and arriving at satisfactory solutions.

Some characteristics of problems are: more time necessary for completion and reflection than daily exercises or practice; they can be complex and less structured;

usually, they can be solved using different strategies; they can have one or more solutions, and they are challenging for the person that is solving them.

When you teach a problem solving lesson, what does it typically look like? I.e. What kind of activities or investigations/problems do you have students complete?

### Self-Efficacy Beliefs PS

When I teach problem solving...

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| I will be able to offer multiple suggestions for creating solutions from data. | ○ | ○ | ○ | ○ | ○ |
| I will be able to provide students with the opportunity to construct alternative solutions for the same observation. | ○ | ○ | ○ | ○ | ○ |
| I will be able to encourage my students to independently examine resources in an attempt to connect their solutions to scientific knowledge. | ○ | ○ | ○ | ○ | ○ |
| I possess the ability to provide meaningful common experiences from which predictable scientific problems are posed by students. | ○ | ○ | ○ | ○ | ○ |
| I have the necessary skills to determine the best manner through which students can obtain scientific evidence. | ○ | ○ | ○ | ○ | ○ |

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| I will require students to defend their newly acquired knowledge during large and/or small group discussions. | ○ | ○ | ○ | ○ | ○ |
| I expect my students to generate questions while investigating problems. | ○ | ○ | ○ | ○ | ○ |
| I will provide opportunities through which students will obtain evidence from observations and measurements. | ○ | ○ | ○ | ○ | ○ |
| I will expect my students make their solutions of their problems public. | ○ | ○ | ○ | ○ | ○ |
| I will be able to provide opportunities for students to become the critical decision makers when evaluating the validity of solutions. | ○ | ○ | ○ | ○ | ○ |

When I teach problem solving

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| I will be able to guide students in asking scientific questions that are meaningful. | ○ | ○ | ○ | ○ | ○ |
| I will be able to provide opportunities for my students to describe their investigations and findings to others using their evidence to justify solutions and how data was collected. | ○ | ○ | ○ | ○ | ○ |

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| I will create (plan) investigations through which students will be expected to gather particular evidence. | ○ | ○ | ○ | ○ | ○ |
| I will be able to negotiate with students' possible connections between/among solutions. | ○ | ○ | ○ | ○ | ○ |
| I will expect students to independently develop solutions using what they already know about scientifically accepted ideas. | ○ | ○ | ○ | ○ | ○ |
| I encompass the ability to encourage students to review and ask questions about results of other students' work. | ○ | ○ | ○ | ○ | ○ |
| I will be able to guide students toward appropriate investigations depending on the questions they are attempting to ask. | ○ | ○ | ○ | ○ | ○ |
| I will be able to create the majority of scientific questions needed for students to investigate problems. | ○ | ○ | ○ | ○ | ○ |
| I possess the ability to allow students to devise their own questions to investigate problems. | ○ | ○ | ○ | ○ | ○ |
| I will be able to guide students to make use of data in order to develop solutions. | ○ | ○ | ○ | ○ | ○ |

When I teach problem solving...

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| I will be able to play the primary role in guiding the identification of scientific questions to solve problems. | ○ | ○ | ○ | ○ | ○ |
| I will be able to guide students toward scientifically accepted ideas upon which they can develop more meaningful understanding of science. | ○ | ○ | ○ | ○ | ○ |
| I possess the abilities necessary to provide students with the possible connections between scientific knowledge and their solutions. | ○ | ○ | ○ | ○ | ○ |
| I will expect students to recognize the connections existing between proposed solutions and scientific knowledge. | ○ | ○ | ○ | ○ | ○ |
| I will expect students to ask scientific questions. | ○ | ○ | ○ | ○ | ○ |
| I possess the skills necessary for guiding my students toward explanations that are consistent with experimental and observational evidence. | ○ | ○ | ○ | ○ | ○ |
| I can develop problems that my students will investigate. | ○ | ○ | ○ | ○ | ○ |

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| I can guide students to create scientific solutions based on evidence. | ○ | ○ | ○ | ○ | ○ |
| My students will derive scientific evidence from instructional materials such as a textbook. | ○ | ○ | ○ | ○ | ○ |
| I will be able to encourage students to gather the appropriate data necessary for answering questions to solve problems. | ○ | ○ | ○ | ○ | ○ |

When I teach problem solving...

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| I will be able to offer/model approaches for generating solutions from evidence. | ○ | ○ | ○ | ○ | ○ |
| I will be able to coach students in the clear articulation of solutions. | ○ | ○ | ○ | ○ | ○ |
| Through the process of sharing solutions, I will be able to provide students with the opportunities for students to critique solutions and problem solving methods. | ○ | ○ | ○ | ○ | ○ |
| I will require students to develop scientific solutions based on evidence. | ○ | ○ | ○ | ○ | ○ |

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| I will expect my students to think about other reasonable solutions that can be derived from the evidence presented. | ○ | ○ | ○ | ○ | ○ |
| I will be able to facilitate open-ended, long-term student-centered problem solving in an attempt to provide opportunities for students to gather evidence. | ○ | ○ | ○ | ○ | ○ |
| I will be able to help students refine questions posed by the teacher or instructional materials, so they can experience both interesting and productive problem solving experiences. | ○ | ○ | ○ | ○ | ○ |
| I will be able to provide demonstrations through which students can focus their queries into manageable problems for problem-solving activities. | ○ | ○ | ○ | ○ | ○ |
| I will require students to develop solutions using evidence. | ○ | ○ | ○ | ○ | ○ |
| I will be able to utilize worksheets as an instructional tool for providing a data set and walking students through the analysis process. | ○ | ○ | ○ | ○ | ○ |

When I teach problem solving...

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| My students will refine their solutions using possible connections to scientific knowledge that has been provided. | ○ | ○ | ○ | ○ | ○ |
| I will be able to model for my students prescribed steps or procedures for communicating scientific solutions to the class. | ○ | ○ | ○ | ○ | ○ |
| I will be able to provide my students with possible connections to scientific knowledge through which they can relate their solutions. | ○ | ○ | ○ | ○ | ○ |
| I will be able to provide my students with evidence to be analyzed. | ○ | ○ | ○ | ○ | ○ |
| My students will engage in problems I have provided them. | ○ | ○ | ○ | ○ | ○ |
| My students will engage in problems that are provided by a variety of sources such as the textbook. | ○ | ○ | ○ | ○ | ○ |
| My students will analyze data that has been supplied, while following teacher instruction. | ○ | ○ | ○ | ○ | ○ |

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| I will expect my students to clarify the problem(s) provided in an attempt to enhance science learning. | ○ | ○ | ○ | ○ | ○ |
| I will be able to provide my students with the data needed to support an investigation of a problem. | ○ | ○ | ○ | ○ | ○ |
| My students will communicate and justify their solutions to the class using broad guidelines that have been provided. | ○ | ○ | ○ | ○ | ○ |

When I teach problem solving...

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| My students will choose the questions they would like to investigate a problem from a list provided. | ○ | ○ | ○ | ○ | ○ |
| My students will analyze teacher provided data in a particular manner. | ○ | ○ | ○ | ○ | ○ |
| My students will form their solutions using evidence that has been provided. | ○ | ○ | ○ | ○ | ○ |
| I will be able to provide my student with all evidence required to form solutions through the use of lecture and textbook readings. | ○ | ○ | ○ | ○ | ○ |
| My students will construct solutions from evidence using a framework I have provided. | ○ | ○ | ○ | ○ | ○ |

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| I will expect my students to follow predetermined procedures when justifying their solutions. | ○ | ○ | ○ | ○ | ○ |
| My students will determine what evidence will be most useful for answering their scientific questions to solve problems. | ○ | ○ | ○ | ○ | ○ |
| My students will design investigations and gather evidence necessary to solve a particular problem. | ○ | ○ | ○ | ○ | ○ |
| I will expect my students to collaborate with me in an attempt to construct criteria for sharing and critiquing solutions. | ○ | ○ | ○ | ○ | ○ |
| My students will share and critique solutions while utilizing broad guidelines that have been provided. | ○ | ○ | ○ | ○ | ○ |

When I teach problem solving

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| I will expect students to use internet-based resources or other materials to further develop their investigations of a problem. | ○ | ○ | ○ | ○ | ○ |

| | Never | Seldom | Sometimes | Quite-a-bit | Always |
|---|---|---|---|---|---|
| I will be able to model for my students the guidelines to be followed when sharing and critiquing solutions. | ○ | ○ | ○ | ○ | ○ |
| I will be able to instruct students to independently evaluate the consistency between their own solutions and scientifically accepted ideas. | ○ | ○ | ○ | ○ | ○ |
| I will expect my students to negotiate with me the criteria for sharing and critiquing solutions. | ○ | ○ | ○ | ○ | ○ |
| I will be able to construct with students the guidelines for communicating results and solutions. | ○ | ○ | ○ | ○ | ○ |
| I will expect my students refine problems that have been provided. | ○ | ○ | ○ | ○ | ○ |
| I will be able to provide my students with solutions. | ○ | ○ | ○ | ○ | ○ |
| I will expect my students to justify solutions using given steps and procedures. | ○ | ○ | ○ | ○ | ○ |
| My students will comprehend teacher presented solutions. | ○ | ○ | ○ | ○ | ○ |

## Demographics

Do you identify as male or female?

○ Male

- Female
- Prefer not to say

How old are you?

- 18 - 24
- 25 - 34
- 35 - 44
- 45 - 54
- 55 - 64
- 65 - 74
- 75 - 84
- 85 or older

What is the highest level of education you currently hold?

- Some college
- Bachelor's
- Some graduate
- Master's
- Ph.D./Ed.D

What discipline in your highest degree in?

Do you currently hold any teaching licenses? If so, what subjects?

- Agricultural Education
- Science
- Other
- I do not currently hold any/ I no longer teach

Which science discipline(s) are you currently certified to teach?

- Biology
- Chemistry

- [ ] Physics
- [ ] Earth Science
- [ ] Other ______

Do you hold any additional certifications or licenses such as CASE or science?

- [ ] CASE Certification
- [ ] Science certification
- [ ] I do not hold any additional certifications
- [ ] Other ______

Which CASE certifications do you currently hold? Select all that apply.

- [ ] Introduction to Agriculture, Food, and Natural Resources (AFNR)
- [ ] Principles of Agricultural Science--Animal
- [ ] Principles of Agricultural Science-Plant
- [ ] Animal and Plant Biotechnology
- [ ] Food Science and Safety
- [ ] Agricultural Power and Technology
- [ ] Mechanical Systems in Agriculture
- [ ] Environmental Science Issues
- [ ] Natural Resources and Ecology
- [ ] Agricultural Research and Development

How many CASE certified courses do you currently teach?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7

- 8
- 9
- 10

How many years have you been teaching, including this year?

What state do you teach in?

- Indiana
- Iowa
- Ohio
- Other

How would you describe the area in which you teach?

- Rural (populations fewer than 2,500)
- Urban Cluster (populations between 2,500 and 50,000)
- Urban Area (populations over 50,000)

How often do you teach a problem solving lesson?

- Once or twice a year
- A few times per year
- Once or twice a month
- A few times a month
- Once a week
- More than once a week

**Block 4**

Thank you again for your participation!! Your expertise in the field is highly valued and will contribute greatly to this project.

Please make sure you click the final arrow to ensure your survey is submitted.