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A Case Study of Undergraduate Students' Experiences When Problem–Solving During a Teacher Preparation Course

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Abstract

The rapid advancement of technology in the 21st Century has created a demand for individuals who can think critically, solve problems, and work effectively as part of a team when entering the global workforce. However, many students have not been adequately prepared to enter the workforce with these skills. In response, this investigation aimed to examine the experiences of undergraduate students in agricultural education when engaging in a real-world troubleshooting experience. The results from the analysis revealed three themes: (1) navigating troubleshooting, (2) cognitive supports, and (3) thinking-about-thinking. These themes illuminated critical factors associated with problem-solving, specifically in the context of agricultural mechanics. Further, the findings also highlighted critical aspects related to the problem-solving behavior model, which illustrated the students' journey through the problem-solving process. Moving forward, we recommend that teacher preparation programs examine students' cognitive and metacognitive abilities. Finally, teacher educators in agricultural education should integrate the problem-solving behavior model into students' preservice coursework, allowing them to experience and develop their instructional acumen in ways that can foster their future students' problem-solving abilities.

Introduction and Review of Literature

In the U.S., school-based agricultural education (SBAE) provides crucial instruction in food, fiber, as well as science, technology, engineering, and mathematics (STEM) to almost 12 million secondary and post-secondary students every year (Advance Career and Technical Education, 2022; National Association of Agricultural Educators, 2023). SBAE enables students to explore opportunities in various domains and acquire skills essential to the global workforce. In the 21st Century, the workforce has evolved from requiring only basic knowledge and skills to a more integrated system that demands individuals possess more advanced communication, problem-solving, critical thinking, and teamwork skills across multiple domains (Jacobson-Lundeberg, 2016; Lumina, 2018). Such skills have become essential for individuals to identify problems, find solutions, and implement their plans effectively (Allen et al., 2011; Hanson, 2006; Weeks et al., 2020). To develop these skills, student-centered classrooms have emerged as a key approach

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to education. As such, the driving principle of any student-centered learning environment is to shift instruction from a traditional lecture format to one that is more open and student-driven. Therefore, students become the focus of their learning. At the same time, teachers transition into a facilitation role, creating a learning environment that provides students with opportunities to interact with real-world, contextual problems (Allen et al., 2011). These classrooms come in various formats, including flipped classrooms, team-based learning (TBL), problem-based learning, experiential learning, and more.

Of those predominant student-centered learning environments, TBL incorporates learning conceptual and procedural knowledge, with collaboration and problem-solving (Michealsen & Sweet, 2008). Michaelsen and Sweet (2008) developed TBL to integrate student collaboration and problem-based learning, utilizing prior concepts to solve real-world problems while providing students with conceptual knowledge and procedural skills. Similar to student-centered approaches, TBL is formatted so that students learn conceptual knowledge in a specific domain before the scheduled class, and during class, they apply that knowledge (Michealsen & Sweet, 2008; Wallace et al., 2014). However, to design a TBL formatted course, there are four key elements: (a) group formation and management, (b) student accountability, (c) timely feedback, and (d) assignment design (Michealsen & Sweet, 2008). Using these elements, the classroom is organized into modules that last one to two weeks (Michealsen et al., 2004). These modules are designed for students to learn the necessary conceptual knowledge outside of classroom instruction and be prepared to engage in classroom application activities. Therefore, assignments must allow students to engage in problem-solving by creating solutions to real-world problems. These application activities enable students to critically analyze, evaluate, and select proper solutions to issues (Michealsen et al., 2004). However, there are few research studies on the use and effectiveness of TBL, especially in agricultural education. Research by McCubbins et al. (2016) examined student perceptions of TBL and found that overall, students in the course were highly motivated by the teaching method. Therefore, indicating that individuals who work in a collaborative environment held higher motivations during the course (McCubbins et al., 2016). Similarly, a study conducted by Figland et al. (2019) yielded complementary results in which students reported being very satisfied with the TBL formatted course and perceived that it promoted the development of positive team collaboration skills, increased problem-solving skills, and self-efficacy. However, for students to gain the necessary problem-solving skills, it is imperative that they have the ability to manage all facets of their cognitive and metacognitive ability. Specifically, they must have an active awareness of *how* they prefer to solve problems, to make decisions during the problem-solving process.

In SBAE, research on problem-solving, cognition, and metacognition has suggested that educators should tailor curriculum and utilize instructional methods to help develop their students' problem-solving skills (Parr et al., 2006; Pashler, 2007; McKim & McKendree, 2020; Figland et al., 2020). In particular, Pashler et al. (2007) advocated for educators to provide students with probing questions that require them to explain their reasoning, thereby promoting metacognition and building students' problem-solving skills. Similarly, Edwards (2004) reiterated that SBAE teachers should incorporate problem-solving skills into their curriculum to expand students' capacity and prepare them for the workforce. In a recent study, McKim and McKendree (2020) suggested placing a significant emphasis on a systems-thinking approach in SBAE classrooms. Utilizing this method could help to develop better problem-solving skills among students (McKim & McKendree, 2020).

Nevertheless, the lack of problem-solving skill development for students in SBAE has persisted and been exacerbated by the limited opportunities for them to acquire new problem-based skills, resulting in many students falling short in key skill attainment (Ulmar & Torres, 2007). According to the Lumina Foundation (2018) and the Partnership for 21st Century Learning (2020), the most essential workplace skills that students need to possess are problem-solving, collaboration, and communication. However, for students to develop imperative problem-solving skills, educators must help students develop their 21st Century skills by utilizing diverse learning methods in their curriculum that target such factors (Blackburn et al., 2014; Chumley et al., 2018; Fuhrmann & Grasha, 1983; Jonassen, 2000; Lamm et al., 2011; Ulmar & Torres, 2007; Weeks, 2020). On this point, Thiel and Marx (2019) explained that SBAE teachers could develop problem-solving skills by utilizing active teaching methods such as inquiry-based instruction, experiential learning, and problem-based learning. Other scholars (Bloom, 1974; Darling-Hammond & Falk, 1997; Dewey, 1944; Figland et al., 2019; Kolb, 1984; McCubbins et al., 2018) have echoed these findings, reporting that active learning environments enhance student learning and can lead to academic success.

Despite these encouraging findings, research in agricultural education has shown that in-service and preservice teachers often lack the higher-order thinking skills necessary to facilitate the acquisition of knowledge and skills related to problem-solving in their classrooms (Smalley et al., 2019; Weeks et al., 2020). In particular, Weeks et al. (2020) reported that preservice SBAE teachers needed the most assistance teaching students critical thinking. Meanwhile, Smalley et al. (2019) found that teaching decision-making skills was a professional development need expressed by SBAE teachers, which aligned with previous research (Joerger, 2002; Layfield & Dobbins, 2002). As the demand for qualified candidates who possess adequate problem-solving and critical-thinking skills continues to rise, especially in technical areas such as agricultural mechanics (Figland et al., 2020, 2021; Jacobson-Lundeberg, 2016; Lumina, 2018), it has become increasingly crucial that teacher preparation programs in agricultural education focus on understanding preservice teachers' ability to successfully implement problem-solving strategies and utilize them as a method of instruction in their future classrooms.

Conceptual Framework

For this investigation, we used existing literature to develop a conceptual model to illustrate how an individual progresses through the problem-solving process, called the model of problem-solving behavior. This model was created to explain individuals' levels of problem-solving ability when they engage in troubleshooting. The intent of the model was to guide preservice teachers as they seek to enhance their problem-solving abilities during a teacher preparation program. Through this enhanced knowledge and skills, agricultural education students could gain greater problem-solving skills and be more inclined to use such an approach with their future SBAE students when they become teachers.

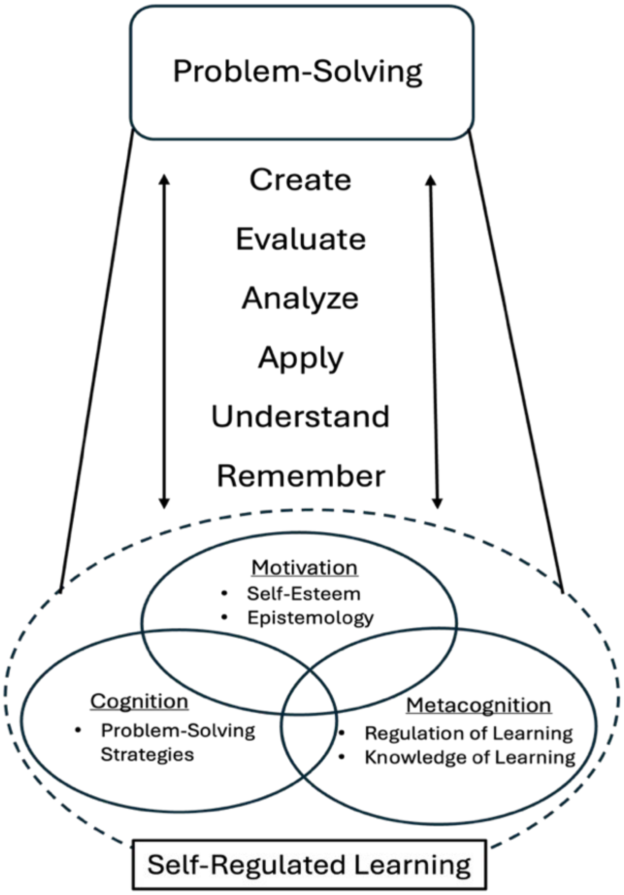
The model (see Figure 1) was grounded in Zimmerman and Risemberg's (1997) self-regulated learning theory and Bloom's (2001) taxonomy of learning. Self-regulated learning theory opines that for an individual to maximize their critical thinking; they must be able to regulate their learning. Within self-regulated learning there are four common assumptions. First, an individual must be active in the learning experience. Meaning they must be cognitively, metacognitively, and motivationally invested in the experience and find value in what they are learning (Zimmerman, 2001). For example, in a small engine unit, all learners would be engaged in disassembling and reassembling a 4-cycle motor. Secondly, self-regulated learning is a constant feedback loop. Specifically, how the learner is monitoring their progress, regarding their goal achievement and external feedback (Zimmerman, 2001). Therefore, active reflection is an integral piece in the regulation process.

The third assumption is the ability of the learner to focus on their goals and use relevant strategies to solve problems (Sitzmann & Ely, 2011). An example of this would be when a student utilizes concept mapping to organize previous information to locate a fault. Finally, the fourth assumption lies within the learner's motivation to complete the task (Schunk & Zimmerman, 2008). Specifically, does the learner find enough value in the task to solve the problem by regulating their learning. Therefore, it is integral to the model that the learner be able to engage in all elements of the self-regulated learning process to problem-solve effectively and efficiently, which is why the process is positioned at the bottom of the model. An individual's maximum critical thinking ability lies at the intersection of metacognition, cognition, and motivation. At this point, individuals can self-regulate their learning and problem-solve at the highest level of effectiveness. However, if a learner is unable to regulate their learning, they will be unable to successfully move through the problem-solving process.

The primary objective of incorporating Bloom's taxonomy of learning into the model was to illuminate the cognitive processes that learners employ to structure knowledge when confronted with novel challenges. By incorporating Bloom's taxonomy, we aimed to comprehend the level of problem-solving that individuals achieve when presented with a problem. If learners can effectively regulate their learning and progress through the problem-solving process, they will ultimately complete it successfully. It is crucial to recognize that learners may initiate the problem-solving process at any juncture and progress through various stages, as indicated by the double-ended arrows on either side of the model.

Figure 1

Model of Problem-Solving Behavior



Note. This model was adapted from Zimmerman and Risemberg's (1997) self-regulated learning theory and Bloom's (2001) taxonomy of learning.

Background of the Study

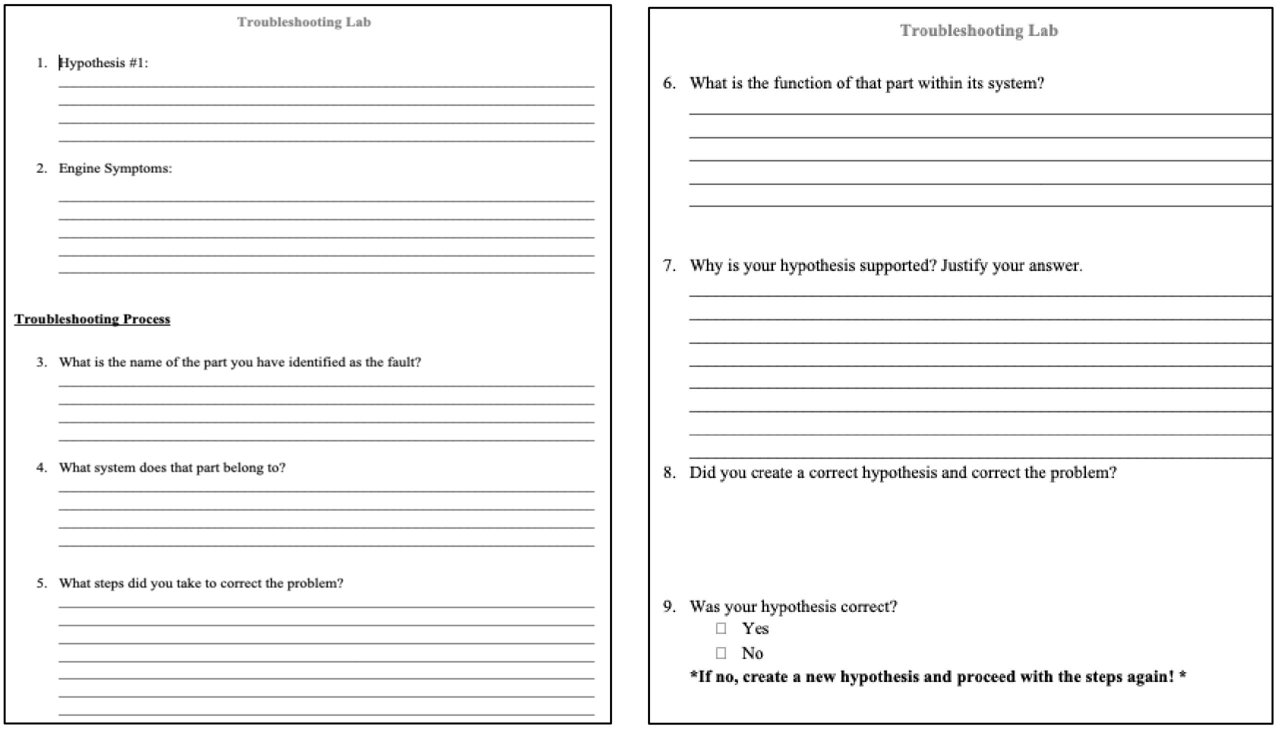
During the spring 2023 and 2024 academic semesters, we used a modified TBL format during the *Introduction to Agricultural Mechanics* course at Louisiana State University. This format was adapted from the guidelines of Michaelson and Sweet (2008) to fit the course objectives and facilitate a student-centered learning environment, allowing students more time in a laboratory setting to apply the knowledge they had acquired through lectures. At the beginning of each semester, students were purposefully grouped into equal teams of four based on their cognitive style score, collected using Kirton's (2003) adaptation-innovation inventory (KAI). Those groups were either homogeneous adaptive, homogeneous innovative, and heterogeneous. The members in each of these groups remained with them for the remainder of the course and completed all necessary coursework. The course was comprised of four modules, including (a) safety, (b) agricultural structures (construction), (c) electricity, and (d) small gasoline engines. For this study, data were collected within the small gasoline engine unit.

Following the TBL format, at the beginning of each module, students would engage with the material before class. These materials consisted of PowerPoint presentations, videos, and readings, and it was expected that students would complete them outside of class time and be prepared to discuss them during class. After reviewing the materials, individuals would then complete their Individual Readiness Assurance Test (IRAT). After the IRAT, the teams would gather and complete the Team Readiness Assurance Tests (TRAT). The TRATs were designed to generate collaboration and teamwork among members on items that were difficult or were incorrect on their IRATs. The TRAT ensured that all members were participating equally and promoted content mastery. After the formative assessments, the remainder of the session was spent in the laboratory, where the students engaged in their application exercises. The application exercises were designed to integrate each student's conceptual knowledge and procedural skills through hands-on activities. Students remained in their teams and were directed to collaborate with those members as a first line of action while completing all course activities. This was done to maintain the course format and promote collaboration and teamwork, which in turn fostered problem-solving skills and developed metacognition.

The current investigation was part of a larger, more extensive study that employed a quantitative treatment. For the treatment, each group's four-cycle gasoline engine was treated with one known fault, which means that all groups received their engines with the same fault to troubleshoot on the day of data collection. It is essential to note that each group received the same engine they had been working on in the previous weeks, and all of them were in proper working order, i.e., running without any problems. Further, each group worked through the troubleshooting problem through a guided problem-solving approach. Below is an example of the guided troubleshooting sheet participants utilized in the troubleshooting application (see Figure 2). The qualitative data for the current study were collected directly after students completed the quantitative treatment.

Figure 2

Guided Troubleshooting Application Sheet



Troubleshooting Lab

1. Hypothesis #1:

2. Engine Symptoms:

Troubleshooting Process

3. What is the name of the part you have identified as the fault?

4. What system does that part belong to?

5. What steps did you take to correct the problem?

Troubleshooting Lab

6. What is the function of that part within its system?

7. Why is your hypothesis supported? Justify your answer.

8. Did you create a correct hypothesis and correct the problem?

9. Was your hypothesis correct?
   - ☐ Yes
   - ☐ No

***If no, create a new hypothesis and proceed with the steps again! ***

Purpose and Research Question

The purpose of this study was to understand the experiences of students in the *Introduction to Agricultural Mechanics* at Louisiana State University when engaging in a real-world troubleshooting scenario. The investigation was part of a more extensive study that examined the effects of metacognitive and cognitive functions on problem-solving ability in the course, employing a mixed-methods approach. Therefore, this study aimed to investigate participants' experiences more intimately when engaging in a real-world troubleshooting experience. One research question guided this investigation:

1. What are the processes (cognitive and metacognitive) that students utilize when troubleshooting a small gasoline engine?

Methodology

To accomplish this study, we employed a case study approach to develop a holistic understanding of the experiences students engaged in during their troubleshooting exercise (Stake, 1995). This case was bounded by time and place and utilized multiple sources of information to ensure data saturation (Stake, 1995). The sources of data included observations, field notes, and student-written reflections. The students had 120 minutes to complete the troubleshooting exercise and written reflections. Data were collected after the troubleshooting application, and all students in this course were asked to complete a written self-reflection about their experience. These reflections emphasized how the groups communicated about solving the problem during the troubleshooting exercise. Specifically, questions pertained to challenges, communication, areas of strength, and evaluation. These questions were asked to gain a holistic understanding of the problem-solving process and its complex nature. All students ($N = 48$) during the 2023 and 2024 spring academic semesters provided data. Demographically, the majority of students were female, classified as juniors, and were agricultural education majors, with a more adaptive than innovative approach to their KAI score (Kirton, 2003).

Data Analysis

After the reflection questions were completed, the initial analysis of the responses began by utilizing Saldaña's (2021) coding suggestions. To gain a deeper understanding of the phenomenon, we used three first-round coding approaches: (a) structural, (b) in vivo, and (c) process. The first type of coding we employed was structural, as it allowed us to initially categorize the data by commonalities (Saldaña, 2021). Thereafter, we employed in vivo coding to gain a deeper understanding of the participants' views and experiences (Saldaña, 2021). Finally, we used process coding to illuminate the process through which participants engaged during the experience. Process coding can be utilized to search for routines as well as "changing and repetitive forms of action-interaction plus the pauses and interruptions that occur when persons act or interact to reach a goal or solve a problem" (Corbin & Strauss, 2015, p. 173). After the first cycle of coding, we engaged in axial coding. Axial coding is utilized to reassemble data that may have been split and "aims to link categories with subcategories and ask how they are related" (Charmaz, 2008, p. 157). Therefore, axial coding helped illuminate the prevailing characteristics of students' problem-solving processes. Finally, the data were presented through themes in the findings section.

Reflexivity

To maintain the quality of this study, it is also essential to acknowledge our biases and previous experiences, which may have influenced the results. The lead author was a high school SBAE teacher for three years, during which she taught agricultural mechanics courses. The lead researcher also utilized an active learning environment that incorporated TBL in all laboratory-based courses. Further, the majority of her graduate studies, both at the master's and doctoral levels, have been dedicated to understanding the effects of cognitive style and metacognition on problem-solving ability and how secondary agricultural education can foster the development of problem-solving skills within its curriculum. Additionally, it is worth noting that she was the primary instructor of the course involved in this research and had extensive interaction with the participants. Therefore, it is possible that her interaction with them could have influenced their overall responses. All other researchers were previous agricultural education teachers and faculty at Louisiana State University, at the time of data collection who assisted with the analysis and interpretation of data. Further, all researchers had experience with agricultural mechanics and using TBL as a method of instruction.

Qualitative Quality

To establish qualitative quality, we utilized the eight criteria advanced by Tracy (2010): (a) worthy topic, (b) rich rigor, (c) sincerity, (d) credibility, (e) resonance, (f) significance, (g) ethical, (h) meaningful coherence. These criteria were embedded in each phase of the study. Table 1 provides an overview of the methods used to ensure the qualitative quality in this investigation.

Table 1

Plan for Building Quality into the Study

Criteria Categories	Strategies
Worthy Topic	Provided statement and the need for the study Collected data in the semester
Rich Rigor	Provided detailed data collection and analysis plans Collected research over 16 weeks Fully described participants and settings
Sincerity	Provided a self-reflexivity statement Outlined limitations
Credibility	Triangulated qualitative and quantitative data Gave thick, rich descriptions within themes Conclusions reflect themes and previous literature
Resonance	Provided a rich and thorough description of the participants Defined the parameters of the study
Significant Contribution	Developed a conceptual framework to understand the problem-solving process
Ethical	Gained IRB approval to work with human subjects (procedural ethics) and Upheld situational and relationship ethics with human subjects
Meaningful Coherence	Stated purpose and objectives Utilized a qualitative design to fit the objectives Triangulated research findings with multiple data source

Findings

To better understand this phenomenon, participants completed individual self-reflection narratives that prompted them to think critically about the problem-solving process they had engaged in. After initial data coding, axial coding was utilized, and three themes emerged, including (a) *navigating troubleshooting*, (b) *cognitive supports*, and (c) *thinking-about-thinking*.

Theme 1: Navigating Troubleshooting

The first theme that emerged was navigating troubleshooting, which explored the problem-solving process that participants experienced while troubleshooting, with a particular focus on the obstacles they encountered. Obstacles emerged as the prolonged complications that slowed students' progression of problem-solving, but did not entirely impede them from arriving at a solution. For example, many teams had difficulty identifying the initial problem but were able to continue through the problem-solving process. When attempting to understand the complex obstacles that the students endured when problem-solving, two sub-themes surfaced: (a) communication obstacles and (b) process obstacles.

Our analysis revealed that students faced challenges in effectively communicating with their partners to solve problems. Some of the teams struggled to communicate throughout the entire process, which caused them to miss steps in the process while also challenging their ability to generate ideas. Participant 33 stated, "We talked, but there wasn't much input from her about the issue at hand." Another explained, "We basically communicated by saying as little as possible" (Participant 17). This was also a common challenge for Participant 35, who received minimal interaction or communication from their partner. However, many participants felt that some aspects of their communication were strong enough to accomplish the task, but they introduced frustrations throughout the process. This sentiment was echoed by Participants 47 and 48, who explained: "We communicated just enough to get the job done, but it could have been better."

The second obstacle to problem-solving emerged during the participants' troubleshooting. Process obstacles were the aspects of problem-solving that hindered students' ability to solve cognitive problems. Of the process obstacles, most participants had difficulty identifying the problem. Participants 9 and 41 corroborated statements that identifying the issue was the most challenging [aspect of the activity]." Meanwhile, Participant 18 explained: "determining the issue was the most challenging because there were multiple reasons that could have been the problem." Further, this sentiment was echoed by Participant 38 who reflected, "determining the issue was difficult because we had to know how the symptoms were affecting the engine." However, the participants also expressed issues with understanding and recalling previous information. According to Bloom (2001), for an individual to successfully problem-solve, they must be able to understand the scenario or problem and then recall domain-specific knowledge by remembering facts and information about the problem. Specifically, many participants reported that it was challenging for them to understand and decipher the given troubleshooting scenario, which hindered their ability to identify the problem further. For example, Participant 2 recalled: "One of the most challenging aspects was understanding the scenario." Further, Participant 3 stated that understanding the scenario was "difficult," but elaborated that "the process of symptom elimination was difficult." This sentiment was expressed by Participants 15 and 17, who also had difficulty processing the scenario because the "symptoms were not explicitly written or given."

In our observations, we captured field notes that chronicled how many of the participants struggled with self-doubt and low self-efficacy while developing their hypotheses. Specifically, many individuals expressed uncertainty about whether their hypothesis was correct and whether they could continue to solve the problem correctly. On this point, Participant 11 stated, "it was challenging to figure out the answer because we weren't sure if we were correct or not to proceed." This was also reiterated by Participant 15 who stated that their self-doubt hindered the development of a hypothesis. Participant 28 also reported: "Our confidence was the main problem [because of this] we continually second-guessed ourselves throughout the process." This lack of self-efficacy may have ultimately affected the participants' ability to regulate their learning fully. According to Zimmerman (1997), an individual must be able to regulate their emotions during the learning process because they often struggle to utilize more complex domains of knowledge fully.

Theme 2: Cognitive Supports

The second theme, cognitive supports, emerged as students described the factors that aided them during problem-solving. Cognitive supports represented the specific resources or services that positively impacted students' problem-solving. One of the most significant cognitive supports identified by many of the participants was having a partner with whom to problem-solve. Participant 10 explained: "having a partner was super helpful [because] the balance of our two brains helped us solve [the problem] faster." Further, Participants 5 and 36 stated that discussing the information in the scenario helped them stay on track. This sentiment was echoed by Participant 43, who said, "[My partner] helped my thinking process [by] talking over parts and explaining the problem." Many teams also elaborated that their partners helped them prioritize their thinking processes. Specifically, Participant 30 stated: “My partner helped to fill in the holes of my ideas. On this point, Participant 45 echoed this sentiment: “My [partner] helped to expand my thinking processes [because] we collaborated and communicated” (Participant 45).

Also, in this theme, students expressed that using the troubleshooting resources was helpful. During the problem-solving exercise, participants had access to their troubleshooting resources, and many of them noted that utilizing their troubleshooting concept map helped identify the problem. Specifically, Participant 22 stated: “having the troubleshooting tree was a good reference to help us narrow down the problem.” Similarly, Participant 40 explained: “the troubleshooting diagram helped to solve the problem by keeping us focused on the main issue and system.” This was echoed further by Participants 37 and 45, who felt that the troubleshooting diagram helped keep them focused and on track. It was also noted that the troubleshooting curricular materials helped to keep the participants engaged with each other and solve the problem. The troubleshooting materials were developed to guide students through the situated problem, utilizing a structured questioning approach based on the conceptual framework for this study.

Theme 3: Thinking-About-Thinking

In the final theme, thinking-about-thinking, the students expressed how they would approach this problem if they encountered it in the future. The majority of participants discussed their preference for more practice with procedural knowledge, so they could become better at applying it to the task. Specifically, Participant 3 stated: “[I] would like to have more knowledge of the engine components [and also] taking apart the engine a greater number of times.” Additionally, Participant 43 reported using a writing strategy in which they wrote down their troubleshooting processes to organize their thoughts.

This led the participants to discuss how they would have solved the carburetor problem differently. Specifically, they illuminated the procedural steps they would have taken to make the process easier. For example, Participants 18 and 38 explained that they would have started by removing the carburetor bowl first, rather than removing the air filter and the entire carburetor. Further, Participant 28 explained that with more knowledge, they would have known to check the carburetor first. Additionally, the majority of participants stated that they would have started by draining the gas tank before attempting to disassemble the carburetor.

Finally, most participants agreed that reflecting on and applying their knowledge to various problem-based scenarios would have been beneficial to their learning. This was expressed by Participants 7 and 33, who stated: “[I would have liked to] learn more about different [troubleshooting] scenarios, so I would be better at applying the knowledge.” In a similar vein, Participant 2 revealed: “having more experience with troubleshooting scenarios would have made us better.” It is essential to note that this was a semester-long course, and the majority of the students in this course had no prior experience with small gasoline engines.

Conclusions, Discussion, Implications, and Recommendations

This investigation aimed to gain a deeper understanding of the processes that undergraduate students use when problem-solving. As a result, three themes emerged, which suggested that for individuals to be successful problem solvers, they must be able to achieve self-regulation. This conclusion illuminated critical factors associated with the problem-solving behavior model, which illustrates the students’ journey during the problem-solving process. Therefore, this finding could expand knowledge of problem-solving and self-regulated learning (Zimmerman, 1997), particularly in agricultural education.

When examining the first theme, participants expressed that communication and process barriers were the most significant factors contributing to troubleshooting navigation. Process barriers were identified as aspects of the process that hindered the student's ability to problem solve, which were cognitive in nature. Many participants reported that understanding the scenario, identifying the problem, and recalling information were difficult, causing them to struggle during the troubleshooting task. This conclusion indicated that students had difficulty with the lower-order thinking skills of Bloom's (2001) taxonomy, which directly related to their metacognitive ability. For instance, if a student lacks the knowledge to interact with the problem, they will be unable to progress through the problem-solving behaviors and achieve higher-order thinking skills. Further research is needed to evaluate the types of problem-solving strategies students are utilizing to solve complex problems. Additionally, more research is also necessary to investigate the metacognitive abilities of SBAE teachers.

In this investigation, we observed that partners who were unwilling or ineffective at communication caused some participants to experience self-doubt because they were unsure whether their hypotheses were correct. This undoubtedly caused frustration and issues with self-efficacy, which could have led to a lack of motivation to complete the task. As noted previously, motivation plays a vital role in the overall regulation of learning and problem-solving ability (Zimmerman, 1997). Perhaps this lack of motivation and self-efficacy was due to cognitive style differences and the inability to overcome such (Kirton, 2003). Based on this conclusion, future research is recommended to investigate the impact of metacognition, cognitive awareness, and self-efficacy on the problem-solving behavior of preservice agricultural education teachers. Additionally, further research is necessary to assess the predictive value of metacognition, cognitive awareness, self-efficacy, and motivation on the problem-solving behaviors of agricultural education majors.

In the second theme, cognitive supports, the participants indicated that having a communicative and willing partner helped them to decide on a problem and complete a hypothesis, which enabled them to be effective and efficient problem solvers. Perhaps this is an essential factor because of cognitive style and cognitive diversity grouping. Specifically, Kirton (2003) postulated that for individuals to work together successfully, they must be able to manage their diverse perspectives and be willing and open to new worldviews. Thus, this conclusion provided insight into the importance of having a partner as a form of support because they were able to manage diverse patterns of thinking. This notion was supported by Kirton's (2003) work, which emphasized that problem-solving becomes easier when individuals can manage their varied perspectives to achieve a common goal.

In the final theme, thinking-about-thinking, participants evaluated their troubleshooting processes after completing the troubleshooting task. All participants expressed a desire for more conceptual and procedural knowledge to become effective and efficient problem solvers. This conclusion was consistent with previous research in cognitive skill acquisition and troubleshooting, which has reported that the more knowledge an individual possesses in a domain, the more likely they are to be better problem solvers (Johnson & Flesher, 1993; Jonassen, 2003; VanLehn, 1991).

Further, according to the model, these conclusions indicated that students placed significant value on lower-order thinking skills to better interact with problems to be solved. Perhaps this was because they had low declarative knowledge utilization and struggled to regulate their knowledge of learning through metacognition (Zimmerman, 1997). As such, this indicated that students felt they needed to better understand knowledge in the domain to regulate their metacognitive and cognitive abilities. This finding was consistent with research in metacognition, which suggests that individuals must be able to regulate their knowledge and cognitive skills to effectively interact with a problem (Cross & Paris, 1988; Stutzman & Elly, 2011; Zimmerman, 1997).

Based on our findings, the following questions were raised for consideration. First, how do we accurately assess a student's problem-solving ability in real-world situations to determine the critical factors associated with the problem-solving process to address knowledge and problem-solving deficiencies? Currently, this study was limited to only students enrolled in this course; therefore, the findings were not generalizable to the entire population. Future research is needed to replicate this study in different content areas that are associated with the preparation of SBAE teachers. Specifically, areas such as horticulture, agricultural business, agronomy/soil science, could be utilized to gain a more accurate representation of the problem-solving model.

Moreover, how can teacher preparation programs for agricultural education utilize the problem-solving behavior model in their current teaching methods? The conceptual framework used in this study sheds light on the critical aspects of problem-solving, which are bolstered by the findings. Therefore, it is essential to continue refining this model and to assess and inform students in agricultural education teacher preparation courses about their preferred cognitive style and metacognitive abilities. These factors have been identified as prerequisites to problem-solving ability and may also influence how they teach such content to their students in the future.

So, how do we best prepare preservice agricultural education teachers to utilize and integrate problem-solving into their future instructional practices in SBAE? Teacher preparation programs for agricultural education should use the problem-solving behavior model, allowing preservice teachers to experience and develop instruction in problem-solving skills that can be applied in the SBAE classroom to enhance student learning. Further, regarding this notion, future research should investigate the methods that teacher preparation programs use to assess students' problem-solving abilities and behaviors. Finally, as a result of this investigation, we also pose the following questions for further exploration: What types of problem-solving strategies are being integrated into the SBAE curriculum? What types of problem-solving opportunities are SBAE preservice teachers engaging in through their coursework? Answering such questions will provide a critical foundation of understanding regarding how we can best serve our students in developing problem-solving skills through teacher preparation in agricultural education.

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