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School-based Agricultural Education Teachers' Experiences During a Year-long Field Test of the CASE Mechanical Systems in Agriculture (MSA) Curriculum

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Abstract

Science, technology, engineering, and mathematics (STEM) applications have become increasingly more commonplace in school-based agricultural education (SBAE) settings in the past few decades. In recent years, Curriculum for Agricultural Science Education (CASE) programming has provided a practical outlet for STEM-focused, inquiry-based teaching and learning activities. The CASE Mechanical Systems in Agriculture (MSA) course was recently field-tested nationally with several SBAE teachers. Framed within Rogers' (2003) diffusion of innovations theory, we sought to study six teachers' experiences when implementing the CASE MSA curriculum throughout the 2018-2019 academic year. Using qualitative research methods, we conducted multiple one-on-one interviews with each SBAE teacher at different parts of their respective academic years. Data were coded in accordance with Merriam's (2009) recommendations. Four dominant themes emerged: (1) the journey toward innovation; (2) learning as you go; (3) logistical and implementation challenges; and (4) students' needs and preferences. Several prominent sub-themes emerged as well. Our findings highlight that although challenges existed, the CASE MSA curriculum was suitable for enhancing the rigor and relevance of these teachers' agricultural mechanics curricula. We recommend CASE MSA curriculum stakeholders collaborate to continuously improve its design and flexibility.

Keywords: Curriculum for Agricultural Science Education (CASE); agricultural mechanics; experiences

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Introduction

School-based agricultural education (SBAE) has evolved considerably since its formal inception under the Smith-Hughes Act of 1917 (National Research Council [NRC], 1988; Phipps

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et al., 2008). Originating as vocational agriculture, much of the curricular focus was on production agriculture-oriented topics such as producing livestock, cultivating row crops, and farm mechanics (NRC, 1988). Over time, however, a growing emphasis was being placed upon shifting the emphasis of SBAE away from vocationally-focused and toward teaching and learning activities geared toward applications of academic knowledge, such as through English language arts and science, technology, engineering, and mathematics (STEM). In 1988, the NRC formally recommended this shift occur in subsequent years to help combat several issues, including declining student enrollment and the need to improve the rigor and relevance of SBAE curricula. As the agricultural industry undergoes constant change and is progressively shifting toward greater applications of STEM content (Doerfert, 2011), these calls to action were timely and designed to be impactful.

Applications of academic content in SBAE have been studied in recent decades. Parr et al. (2006) noted teaching mathematics concepts contextually through agricultural mechanics can positively impact student learning outcomes. Haynes et al. (2012) suggested student learning of academically-focused content can be supported when taught through a practical, familiar context such as SBAE courses. Parr et al. (2008) reported contextually teaching mathematics via agricultural mechanics "did not significantly diminish students' acquisition of technical competence" (p. 68). Moreover, agricultural teacher educators (Swafford, 2018), SBAE teachers (Stubbs & Myers, 2015), school administrators (Ulmer et al., 2013) and science teachers (Thompson & Warnick, 2007) see value in using SBAE to contextually teach academic concepts. SBAE teachers exhibit a degree of confidence with integrating biological science concepts within their courses (Chumbley et al., 2019). As noted by Balschweid and Thompson (2002), SBAE teachers often have positive attitudes regarding teaching applied science content within their courses. Such findings positively indicate value in, support for, confidence in, and attitudes toward addressing academic content within the context of SBAE do exist.

As SBAE has evolved in recent decades, the expectations for effective teaching practices have likewise been impacted. Effective SBAE teachers are knowledgeable in agricultural subject matter (Eck et al., 2019) and proactively, contextually teach academic concepts throughout their curricula (Roberts & Dyer, 2004). As greater calls for academic content application in the context of SBAE have been sounded, expectations have increased for teachers to respond (McKim et al., 2016). Robinson et al. (2018) posited about SBAE teachers' potential for effectively and robustly teaching academic content, opining "[SBAE] teachers can lead the charge on STEM education, honing the innovative techniques and providing exemplars for best practices in the field of STEM education" (p. 263).

Beyond STEM, English language arts content in the context of SBAE has also been studied. When examining applications of content area reading in SBAE, Park and Osborne (2006a) indicated while "teachers place high value on reading in agriscience… [they] were in less agreement as to their role and responsibility in teaching students reading skills" (p. 10), indicating SBAE teachers may not perceive they have a role in facilitating students' reading skill development. Moreover, Park and Osborne (2006b) expressed SBAE teachers in their study "valued content area reading, [but] they had implemented little reading and few or no CARS [content area reading strategies] in their agriscience courses" (p. 46). Further, Park and Osborne (2007) presented a model for the study of reading in SBAE. This model consisted of a variety of variables related to students, teachers, contexts, and so forth, designed to provide insight into the variables affecting content area reading in SBAE, including teachers' attitudes and teacher preparation. Haynes et al. (2014) noted preservice teachers believed SBAE courses could be used to emphasize a variety of core academic content and an individual "teacher's background ultimately affects which core subject areas teachers emphasize more regularly in their agricultural education curriculum" (p. 201).

The integration of career and technical education (CTE) and core academic content can be a challenge for many CTE professionals (Drape et al., 2016). Quality professional development in programs such as the Curriculum for Agricultural Science Education (CASE) can help address these concerns. Sustained professional development has shown to support STEM reform (Capraro et al., 2016). Previous research has shown high-quality teacher professional development (PD) typically has statistically significant, positive effects on teaching practices and student outcomes (Darling-Hammond, 2010; Nadelson et al., 2013). Opportunities for active learning and continual growth add to the success of teachers PD (Guseky & Yoon, 2009; Smith & Smalley, 2018).

CASE curricula are designed to be an innovative and integrated approach to teaching and learning in SBAE settings. It is guided by an inquiry-based, scientific approach to teaching in SBAE programs (Velez et al., 2015). This interdisciplinary curriculum allows teachers and students to learn complex systems within a familiar context. Understanding complex systems is a key skill to success in agricultural, food and natural resources (AFNR) education (Culhane et al., 2016; McKim et al., 2018). McKim et al. (2018) found CASE-certified teachers had slightly higher perceived science knowledge than non-CASE-certified teachers. CASE curricula have shown to be beneficial to teachers who are developing their innovative classroom (Velez et al., 2015). As the integration of core academic subjects into SBAE continues to be struggle for some teachers, research into innovative programs like CASE continues to remain important.

Theoretical Framework

Rogers' (2003) diffusion of innovations theory provided the broader theoretical framework for this study. More specifically, Rogers' (2003) model of the five stages in the innovation-decision process guided our study. According to Rogers (2003), "diffusion is the process which (1) an *innovation* (2) is *communicated* through certain *channels* (3) over *time* (4) among the members of a *social system*" ([emphases in original] p. 11). The four main elements of the diffusion of innovations (i.e., innovation, communication channels, time, and the social system) are applicable in every diffusion program (Rogers, 2003). Rogers (2003) described the diffusion of innovation as a social process where individuals mainly rely on subjective evaluations of other individuals to evaluate a given innovation. The communication channels have an impact at all stages of adoption.

Time is an important element in the diffusion of innovations as it pertains to the: (1) innovation-decision process, (2) an individual's earliness / lateness to adopt an innovation, and (3) the overall rate of adoption of an innovation within a system in a given time period (Rogers, 2003). Individuals have been classified by various adopter categories (i.e., innovators, early adopters, early majority, late majority, and laggards) to describe latency of their decision to adopt an innovation. The social system, or interrelated individuals who collaborate to evaluate an innovation, is another important element of the model. These four diffusion of innovation elements serve to guide and inform individuals as the progress through the various stages of adoption (i.e., knowledge, persuasion, decision, implementation, and confirmation).

In the context of our study, SBAE teachers (i.e., the social system element) described their adoption and implementation experiences with the newly developed CASE Mechanical Systems in Agriculture (MSA) curriculum (i.e., the innovation element). The SBAE teachers who provided feedback about their experiences with CASE MSA training and implementation of the new curriculum were the first set of teachers to adopt the aforementioned curriculum (i.e., the time element). The present study also inquired about various influences which impacted the SBAE teachers' decision to adopt the new curriculum (i.e., the communication channels element).

Based on the participant inclusion criteria for this study, all SBAE teachers who participated in our study had progressed to, at least, the fourth sequential stage (i.e., implementation) of the adoption process. However, Rogers (2003) noted every stage of the innovation-decision process serves as a potential point to actively or passively reject the innovation. Evaluating the SBAE teachers' omnibus views of the CASE MSA curriculum and associated training provide insight on the teachers' intentions to continue using the curriculum or possibly experience dissonance and choose to discontinue their adoption of the CASE MSA curriculum.

Purpose and Objectives

The purpose of our study was to explore the experiences SBAE teachers had when implementing the CASE MSA curriculum in their respective programs. Our purpose was based upon the eight research questions that ultimately guided our study:

1) Why did SBAE teachers chose to implement the MSA curriculum in their programs?
2) How have SBAE teachers implemented the MSA curriculum in their programs?
3) What procedures do SBAE teachers use when preparing to teach the MSA?
4) What teaching approaches do SBAE teachers use when teaching the MSA curriculum?
5) What challenges / successes do SBAE teachers experience when teaching MSA curriculum?
6) How do SBAE teachers address fidelity of the MSA curriculum as they implement it?
7) What are SBAE teachers' future plans regarding teaching the MSA curriculum?
8) What, if any, changes to their professional practice do SBAE teachers plan to make or would like to make as related to CASE course implementation?

Our study aligned with Research Priority 2 of the American Association for Agricultural Education (AAAE) National Research Agenda (NRA): New Technologies, Practices, and Products Adoption Decisions (Lindner et al., 2016). Lindner et al. (2016) noted "[e]ducation programming and *practices* (emphasis in original) include face-to-face instruction, lecture, demonstration, experiential learning, simulations, web-based instruction, flipped classroom instruction, farmer field schools, and professional learning networks" (p. 20).

As an innovative educational practice, CASE curricula development was initiated in 2007 under the direction of the National Council for Agricultural Education (CASE, n.d.c). CASE curricula adoption and use has continued to increase in recent years (CASE, n.d.a). Moreover, as a practical, science-focused, innovative educational resource that focuses on using inquiry-based learning to guide students in the learning process (CASE, n.d.c), recent expansions of CASE curricula to include agricultural mechanics is timely. Agricultural mechanics has a historical role in SBAE (Burris et al., 2005) and has traditionally included numerous subject matter areas, including small gas engines, building construction, and welding and metal fabrication (Hainline & Wells, 2019). Naturally incorporating a considerable degree of applied academic content, agricultural mechanics can serve as a useful, suitable vehicle for providing contextually-focused instruction in core academic concepts (Parr et al., 2006).

Developed for field testing during the 2018-2019 academic year, the CASE MSA curriculum incorporates a wide range of agricultural mechanics topics within its design, including electrical systems, power equipment technology, and structural systems (CASE, n.d.b). As such, it stands to reason examining how and why some SBAE teachers have elected to incorporate a recently-developed, innovative, inquiry-based approach to teaching agricultural mechanics is warranted. Perhaps understanding such reasons could be useful in charting the course for future innovative teaching practices for teaching agricultural mechanics in SBAE programs.

Methods

Recruitment

Our study was initiated upon Iowa State University (ISU) Institutional Review Board (IRB) approval. A recruitment e-mail containing information about the study, participation requirements and expectations, and a link to an electronic informed consent form was sent to all 13 teachers who attended the MSA CASE Institute (CI) during the summer of 2018. Six teachers who were able to implement at least some portions of the MSA curriculum in their programs during the 2018-2019 academic year signed the electronic informed consent form and participated in our study.

About the Participants

Three teachers were male and three were female. Five teachers described their respective school locations as rural. The average years of agricultural teaching experience was 16.17 years (*SD* = 13.98), with an average of 6.08 years (*SD* = 4.84) of agricultural education teaching experience at their present school. The average number of students enrolled in the teachers' SBAE programs was 136.50 students (*SD* = 107.62). Regarding CASE certifications prior to engagement in this study, all teachers were CASE MSA-certified and five teachers held certifications in other CASE curricula (see Table 1). It should be noted pseudonyms were used in place of the teachers' actual names.

Table 1
Summary of SBAE Teachers CASE Certifications and Available Facilities for Teaching MSA

Characteristic	Julie	Sue	Kate	John	Gary	Paul
CASE certifications						
Mechanical Systems in Agriculture (MSA)	x	x	x	x	x	x
Introduction to Agriculture, Food, and Natural Resources (AFNR)	x	x	x		x	x
Agricultural Power and Technology (APT)		x			x	x
Principles of Agricultural Science - Animal (ASA)	x	x				x
Facilities used to teach CASE curricula						
Agricultural mechanics laboratory (metals / woods)	x	x	x^2	x	x	x
Greenhouse	x	x		x	x	x
Classroom		x	x		x	x
Sink facility / kitchen		x		x		
Science laboratory	x					
Small engines laboratory	x					
Computer laboratory				x		

Note. ^{2} = signifies the teacher has two of the given facility.

Five teachers were previously certified in the CASE AFNR curriculum and three teachers held CASE APT curriculum certifications. Three teachers were previously certified in the CASE ASA curriculum and two teachers were certified in the CASE NRE curriculum.

Data Collection

Data were collected via two electronic one-on-one interviews conducted with each SBAE teacher throughout the 2018-2019 academic year. Each interview session was audio-recorded. The initial interview with each SBAE teacher was conducted at least one month into the course(s) in which the CASE MSA curriculum was being used. The second, follow-up interview was conducted during the latter half of the course(s) in which the CASE MSA curriculum was being used. Some teachers' schools used year-long course schedules while others used semester- and trimester-long courses, thus impacting the timing of each interview. The timing of each interview was intentional, as we sought to grant each teacher enough time to adequately implement the CASE MSA curriculum within their courses.

We developed and used two different semi-structured interview protocols to guide each one-on-one interview session (see Tables 2 and 3). The protocols were developed by the researchers and were designed to help elicit information about the teachers' experiences with teaching using the CASE MSA curriculum at differing points in time throughout their courses. In addition to the written list of items used for each interview, probing questions were also used. During each interview session, field notes were taken and were used in both the member check and data analysis processes.

Table 2
Items Used During the Initial Interview

Interview Items
Describe why you chose to implement the CASE MSA curriculum in your program.
Describe how you have implemented the CASE MSA curriculum in your program this year.
Describe your procedures for preparing to teach the CASE MSA curriculum.
Describe the teaching approaches you have used when teaching the CASE MSA curriculum.
Describe any challenges you have experienced when teaching the CASE MSA curriculum.
Describe any successes you have experienced when teaching the CASE MSA curriculum.
Describe the fidelity of the CASE MSA curriculum as you have implemented it thus far.
Describe your future plans regarding teaching the CASE MSA curriculum.
Based on your experiences thus far, describe any changes to your professional practice that you plan to make or would like to make as they relate to CASE course implementation.

The purpose of these second, follow-up interviews was to review information from the initial interview to ensure accurate representation and understanding of the information (i.e., member checking) and to better understand how the experience of implementing the CASE MSA curriculum had evolved over time (see Table 3).

Table 3
Items Used During the Second, Follow-up Interview

Since the last time we spoke…
How have your procedures for preparing to teach CASE MSA curriculum changed?
How have your teaching approaches for the CASE MSA field test course changed?
What modifications do you plan to make to the CASE MSA field test course in the future?
How have challenges or successes you experienced with the MSA curriculum evolved?
How have your perceptions of CASE MSA fidelity evolved as you implemented it?
Based on your experiences, describe any changes to your professional practice that you plan / would like to make related to CASE course implementation broadly speaking.

The follow-up interview protocol also included background and demographic questions (i.e., previous CASE certifications, teaching experience, school characteristics, and available facilities). We sent an e-mail to the six SBAE teachers who participated in the initial interview to help establish a time for the second, follow-up interview session. All six teachers participated in the second, follow-up interview. Each interview session was independently transcribed and re-checked for accuracy.

Data Analysis

To promote trustworthiness of results, we employed established qualitative methods. As transcriptions were reviewed, responses were open-coded by each of us (i.e., researcher triangulation). The identified codes were compared and a master list of codes was created (Merriam, 2009). These codes were grouped using axial coding, categorized systematically, and informed by our study's purpose (Merriam, 2009). Transcriptions were reviewed and categories were refined, revised, and consolidated as analysis continued. Finally, primary categories or themes were named. The findings were cautiously analyzed, and statements were contemplated before being subjected in the final draft. Trustworthiness of data was established through our use of a research log and by peer review of data analysis (Creswell, 2013; Merriam, 2009). Another important step we included was bracketing, which strengthened the trustworthiness of the study (Merriam, 2009).

Subjectivity Statement

Regarding Merriam's (2009) recommendations for strengthening trustworthiness of our study, it is appropriate to discuss bracketing to identify any potential biases which could have been present based on our own experiences with SBAE prior to the initiation of this study. As authors, we each have differing and sometimes overlapping experiences related to the teaching and learning processes in SBAE. We are each former SBAE teachers and bring a wide range of backgrounds related to teaching and learning in agricultural education settings. Two of us actively facilitate and hold CASE certifications.

Results

Four major themes in conjunction with six sub-themes emerged from the interviews we conducted. The themes and sub-themes included *the journey toward innovation*, *learning as you go* (i.e., *learning with the students* and *experience prompts changes*), *logistical and implementation challenges* (i.e., *equipment and material requirements* and *program set-up as a restriction to implementation*), and *students' needs and preferences* (i.e., *successes* and *challenges*).

The Journey Toward Innovation

The SBAE teachers who participated in the CASE MSA field test course indicated their participation and desire to earn the CASE MSA certification were associated with their drive to enhance the agricultural mechanics components of their respective SBAE programs. When asked about their motivation to implement CASE MSA in their programs, Gary and Paul believed the curriculum would assist them in providing a stronger focus on STEM concepts and bolstering the rigor of their agricultural mechanics courses. Paul stated, "[i]t [MSA curriculum] is an exciting curriculum and it takes something which is thought of as 'dumb ag. mech.' and it brings out the technical side for the stuff to work." Gary felt like some of the topics included in the CASE MSA curriculum (e.g., robotics, electronics, small gas engines, structures, geographic information systems [GIS]) were very relevant and should be covered when trying to align with 21st century agricultural mechanics topics.

Paul's motivation to implement the CASE MSA curriculum was also linked to his desire to shift his agricultural mechanics course from teacher-centered learning to student-centered learning. Congruent with Paul's desire for student-centered learning, Gary noted he likes how the CASE MSA curriculum "puts the kids in charge of their learning." When talking about his desire to implement student-driven learning activities, Paul said, "I love the idea of being able to start one of the APPs, give them the stuff and let them go with it, and walk around and interact with the students and have those personal interactions." Paul perceived the personal interactions with students were important for building rapport and were just as important as what he teaches in his class. Paul finished his reflection on this topic by stating, "CASE [MSA] gives me the chance to have more of those interactions and that is the direction I want to go towards."

The teachers indicated they were also motivated to implement the CASE MSA curriculum because they believed it provided students with industry-focused applications associated with employment preparedness. When discussing the engine tear-down and re-build activities Julie implements in her small gas engines course, she questions how the learning activities relate to needed skills and knowledge her students need to gain employment. Julie stated, "You can't make money doing small engine repair, so we need to move away from traditional shop-based classes, and I want to teach them a skill and then let them apply it." She also said she would "catch myself telling students to do certain things with engines, but I had nothing to help them to apply it to."

Julie noted, the CASE MSA curriculum implementation provides a foundation for talking about the new technologies and engineering concepts that underpin engine theory. She believes this transformation in curriculum and the way she teaches her small gas engine course will ultimately make her students more employable. With a similar sentiment, Paul indicated the CASE MSA curriculum allows students to explore scientific principles and gain a better understanding of "why they work the way they do." Moreover, Paul felt the CASE MSA curriculum topics (e.g., robotics and 3D printing) aligned with skills needed to gain employment in emerging industries. Paul said his motivations to incorporate learning activities associated with robotics and 3D printing were tied to programming and manufacturing—career options he perceived to have growth in the future. Paul noted, "[I]f they are able to do 3D modeling and small scale renders, that is something [that] I think will be important for people going into any type of manufacturing jobs in the future."

Learning as You Go

While the teachers were excited about the CASE MSA curriculum and felt positive about the benefits it would have for their students, they grappled with the challenge of effectively implementing this curriculum and achieving some sense of competence related to these novel topics. The teachers indicated the MSA CI allowed them to walk through the curriculum lesson-by-lesson, but when they were tasked with facilitating the lessons for their students, they were often learning or re-learning with their students. As a part of the teaching process, teachers also reflected on areas which they wish to improve in the next time they teach the CASE MSA curriculum.

Learning with the Students

Many teachers noted they felt they became a learner along with their students when walking through the CASE MSA lessons for the first time. Some teachers, such as Kate and Sue, claimed they do not have a strong agricultural mechanics background, which forces them to read ahead to stay on-pace with their students. Sue revealed before using the CASE MSA curriculum, her agricultural mechanics courses mainly focused on what she felt were fundamental concepts and skills associated with electrical wiring, welding, and woodworking. Sue noted she has learned from her students during some of the CASE MSA lessons which focused on small gas engines, structures, drafting and design, and robotics. Sue stated, "I don't like to not know the answer so it has been kind of difficult for me. I am having to learn along with my students which has been a frustrating and humbling experience." Sue thought she needed to accept some students might have a stronger understanding on certain topics. Sue noted the experience was "difficult, but it is good for students to see I am a human being just like anyone else and I don't know everything."

In contrast to the aforementioned teachers, Gary, a teacher with over 30 years of experience teaching agricultural mechanics, indicated he struggled keep up with some of the technology used in the CASE MSA curriculum. Gary admitted he had limited computer-aided design (CAD) experience and struggled with the Onshape design software. His lack of background knowledge with CAD software drove him to rely on his tech-savvy students to make sense of the process. As a course facilitator, Gary explained he works closely with his students to help anticipate upcoming issues. Similar to Gary, John believes his students have taught him a lot about the course he did not know as a teacher. John teaches in a small school and only has two students in his CASE MSA-focused course, so when there is a CASE MSA activity which requires three partners, he frequently takes on the role of a student.

Experience Prompts Changes

The teachers commonly noted their experience in the MSA CI and their experience with teaching the curriculum for their first time has provided them with insight on changes that they will make in the future. In regard to first-hand learning experiences in the CI, Kate indicated her learning experiences in the CI allowed her to pinpoint which concepts her students would struggle with they engaged with the CASE MSA curriculum. In agreement with Kate, Gary noted his struggles in the CI associated with some topics (e.g., online global positioning system [GPS] / geographic information system [GIS]) gave him a grasp on the areas his students would experience issues and frustrations with. Gary indicated he put extensive time into better understanding these concepts before introducing them to his course so he would be better prepared lead students thought the activities and projects. While Paul felt prepared to teach the CASE MSA curriculum after his CI experience, he had a semester gap between the CI and the first time that he taught the curriculum. This presented to him the need to brush up on the material. When discussing his process of re-familiarizing himself with curriculum, he said, "[Regarding] the coding for the robotics…or 3D design principles, I will have to practice to keep sharp on because it is something if I don't use I will forget it."

Sue indicated her experience with using the engineering notebook at the CI has prepared her to teach about this aspect of the curriculum and her notebook serves as a good reference for herself and her students. Sue stated, "I can tell them that I know what they are going through and I use it as an example for them to buy in to the process of using the notebook." Sue thought she may have not required students to use the notebook if she didn't have a chance to experience its value first-hand.

Sue indicated she saw value in using the notebook, but after a few units she started to augment the way she used them in her course. For example, she indicated her students became frustrated with some of the redundancy between what they answered on worksheets and the entries they were required to make in the notebook. Therefore, she gives modified instructions to remedy this issue. Other teachers, such as Gary, Julie, and John, had strong opinions about the utility of the engineering notebook and either augmented its use or deleted it from the curriculum altogether. For example, Gary said he has followed the CASE MSA curriculum closely with an exception of using the engineering notebook. Similar to Gary, Julie eliminated the use of the notebook because she said it was too technical for her special needs students. She also modified the CASE "check for understanding questions" on each worksheet by changing them from open-ended questions to more simplistic, short answer questions. She noted it made it easier to grade everything and it boosted the students' scores. John perceived the engineering notebook to be redundant and somewhat of a distraction to his students. He said, "I will probably do away with the engineering notebook. I think it becomes too much with having the CASE notebook, recourse notebook. It is too much to have out."

Aside from modifications associated with the engineering notebook, teachers have made (or plan to make) some augmentations based on their specific needs. When asked about the extent to which he used the CASE MSA curriculum with fidelity, Paul revealed there were some "modifications, deletions, and additions I make and I know this is not the [CASE] way and it is not a lack of appreciation for what they do at CASE, but I have not stuck to the [CASE MSA] curriculum." In fact, Paul indicated the only lesson he taught "as-is" from the CASE MSA curriculum was the building materials strength testing. On the other hand, Gary was persnickety about following the curriculum as written but he made some additions to assist his students. He indicated he developed the practice of taking more pictures of completed projects, he put the objectives on a Microsoft PowerPoint presentation, and he has saved student work samples to serve as a reference for future students.

Julie, who mainly used the small gas engines portion of the CASE MSA curriculum, noted she weeded through the unit and removed some things. She felt the videos were not very helpful for her students, so she cut down on her use of demonstration videos. In place of the videos, she went back and added some procedural items to add clarity to the lessons. Unlike many of the other teachers, Julie had implemented the CASE MSA curriculum twice, which gave her the opportunity to fine-tune the way she used the curriculum. One of her main reflections from the first time she taught it was she was still acting as the "authoritative teacher" and not as the facilitator. Julie explained, "I have changed my teaching approach by being more hands-off. I have to let the student's problem-solve on their own." She admits this change has extended the time it takes to navigate through each activity but she is training students to do the technical reading on their own. She explained, "[t]his is what industry needs from workers, so my teaching strategies [are] to have them go over the purpose of the lab and then I have to be confident to let them go on their own." Julie believes her students take more pride in their work when they are forced to be autonomous.

The teachers also provided input on how they plan to change the structure of their own course curricula to better serve their students. Both Julie and Sue felt the CASE MSA curriculum could be broken down into multiple semesters to enhance their teaching effectiveness. Julie mentioned she may break down the curriculum between two to three courses while Sue said, "I could see myself splitting this class into a Unit A and a Unit B. Like maybe units one through three in one year and four and five in another year." Sue also suggested the fifth unit could be separated into its own independent study course for students who need course credit but have schedules which restrict them from enrolling in SBAE courses. Gary is not planning on making any major changes to his teaching of the CASE MSA curriculum; however, he saw value in alternating the CASE APT and MSA curricula every other semester. He believes the rotation will assist his students with acquiring fundamental concepts in APT which they will be able to apply when taking the CASE MSA curriculum the following semester. Parallel to Gary's thought process, Julie switches back and forth between the CASE APT and MSA curricula within the same course.

Logistical and Implementation Challenges

The SBAE teachers in our study commonly discussed challenges and programmatic barriers they faced when attempting to implement the CASE MSA curriculum in their programs.

Equipment and Material Requirements

The procurement and specificity of equipment and materials needed to teach the CASE MSA curriculum served as an implementation barrier for the teachers. Julie indicated she was concerned with securing funding to implement CASE MSA. She estimated the minimum it would cost for base-line supplies would be $14,000. While she received some grant funding, she was planning on submitting more grant applications to purchase additional supplies related to GIS, GPS, and robotics systems. Julie explained she will have to adjust the way she teaches the course based on whether she is able to secure funding or not.

Sue was also able to secure grant funding, but had to hold off on buying some specialty supplies until she had received more funding. She also noted she had to be creative with finding others who would lend her supplies. Sue stated, "[r]ight now I am having to borrow three 3D printers from the middle school because I didn't have the money to do it. I am not against sharing these, but it would be nice to have our own." She further explained, "[w]e are proud of our agriculture department and we want good, quality things." She admitted finding funding for the initial start-up was the most expensive task and she will have reinvent the wheel to keep the courses funded and have the necessary equipment to give the students the full CASE MSA experience.

Some teachers were successful in securing funding needed to purchase the supplies and equipment necessary to implement the CASE MSA curriculum, but they were experiencing difficulty ordering the supplies from vendors. Gary and Paul were both working through these issues at the time of the first interview and the second, follow-up interview. Paul indicated some of the specialty robotics equipment was exclusively produced by a small technology company that has a long turnaround on product delivery. He was warned about this issue by a science teacher at his school and by the lead teachers at the CI. He chalked up this issue as "one of those things where [a small technology company] ha[s] more growth than they are ready for." During the second, follow-up interview, Paul said it had been three months since he ordered these CASE-recommended supplies and he was still waiting to receive them.

The specificity of the supplies used in the CASE MSA curriculum served as an issue for teachers who had different supplies or textbooks. For example, Sue had engines for her students to work on but they did not match up with the model of engine used to write the textbook. The curriculum writer chose one engine to use on certain tear-down / re-build and troubleshooting exercises. If teachers did not have the exact engines, they were either forced to purchase new ones or re-write certain parts of the curriculum to accommodate the differences between engines. Another example of a required material is the textbooks which are specifically used to supplement the curriculum. Gary was forced to use the textbooks his school already had. Gary noted, "[t]hey have a number of readings which are tied to textbook which I do not have." He had to improvise and locate other sources of information to help his students to grasp certain concepts.

Program Set-up as a Restriction to Implementation

Along with the teachers' struggle to secure needed equipment to teach the CASE MSA curriculum, the teachers also indicated they faced programmatic roadblocks when attempting to integrate the new curriculum in their existing programs. Paul explained because of state-mandated standards, he doesn't "have free reign to go whole-hog on [his] CASE courses." He expressed discouragement with the lack of guidance provided by his state's agricultural education leaders. He is a strong advocate of the CASE curriculum and wishes he could find a better way to link the CASE curriculum with state mandates. Paul noted he had to develop ways to teach material not covered by CASE. Paul stated, "I have to find the APPs which fit what I need to do. I know this is not the CASE way but I don't get support from my administration."

Kate's concerns with the full implementation of CASE MSA curriculum was its misalignment with co-curricular events. Specifically, she was concerned CASE MSA would not prepare her students for the FFA Agricultural Mechanics Career Development Event (CDE) in her state, which only focuses on welding. John noted he would not be able to teach some CASE MSA topics because his school feels it conflicts with other developed courses in his school. For example, John does not teach the small gas engines portion of the CASE MSA curriculum because there is already a small gas engines course at his school.

Other school-based programmatic barriers the teachers noted was the dispersion between the curriculum schedule predicated by CASE and the scheduled course duration in their local programs. For example, Paul stated he was attempting to manage the schedule discrepancy associated with CASE because the CASE MSA curriculum is designed for a year-long course and he only has his students for one semester. John explained he only has 47 minutes a day for one semester and he expressed frustration associated with completing lessons. He also noted the students' inability to finish projects in one course meeting meant he had to find room to store partially-completed projects so students could finish the following day. This was a significant challenge for him based on his limited instructional space. Additionally, John and Kate offered their schools' no-homework policies further exacerbated the issue with guiding students through the CASE MSA curriculum.

Julie indicated her nine-week course was too short to implement the CASE MSA curriculum with fidelity. She said it took her students about three weeks to figure out that there might not be a right or wrong answer and she had to "modify everything so they weren't overwhelmed with the content. I need a few more years to train the students on using CASE before I remove the modifications." In fact, Julie noted some of her students had to come in on a day school was out because they didn't have their engines back together. She said her intentions of keeping them after school to finish up coursework was to keep the students "accountable and teaches them to use time management, which prepares them for industry."

Sue also felt like the CASE MSA curriculum took more time than what CASE prescribed. She tried to pay attention to the CASE timeframe, but a CASE two-day lesson would take her students four days to complete. Sue indicated some errors students made on the student-centered learning activities resulted in activities taking even longer to accomplish. She was also dealing with unique implementation challenges because she was also allowing her student teacher who had no previous experience with the CASE model to help teach the CASE MSA curriculum. Sue concluded her remarks by adding, "[w]e are on a seven period day and I think if I was on a block schedule it would be easier for me to facilitate these lessons." As previously noted in the "experience prompts changes" sub-theme, many teachers were devising plans at the end of the semester to make scheduling augmentations to more effectively implement the CASE MSA curriculum.

Students' Needs and Preferences

When the teachers were asked about the CASE MSA curriculum implementation, they commonly described how the curriculum addressed their students' needs and learning preferences. The teachers outlined many positive impacts the curriculum had on their students and how the activities provided linkages between agricultural mechanics and the students' areas of interest. Despite the myriad of student benefits' espoused by the SBAE teachers, they also mentioned some challenges and pitfalls associated with students' needs and preferences.

Successes

The teachers expressed one of the biggest successes of the CASE MSA curriculum adoption was student "buy-in." Sue and Julie felt this curriculum reinvigorated their students' interest in agricultural mechanics because it offered learning experiences outside of the vocationally-oriented agricultural mechanics model. Kate said her students took the course because they thought it was going to be a welding course and were surprised and excited to have a course which incorporated innovative activities and projects. Sue noted this served as a source of conflict initially because her students were expecting a traditional agricultural mechanics course and had no idea they would be working with advanced technology. While Sue's students were initially apprehensive about the shift in curriculum, they found value in the CASE MSA curriculum once they were immersed in learning.

Julie noted her students loved the new curriculum and it shifted her small engines course "from one where students were dumped into, into one which they want to be in." She also signified some of her students who had taken the course before CASE MSA curriculum integration had a desire to re-take the course with the new curriculum. Kate and John also said they had students who expressed an interest in taking or retaking the CASE MSA-focused course based on how it linked to their interest. John noted his agricultural finance course students, who were not traditional agricultural kids, who wanted to take "[MSA] in the future because they got a new view of what agriculture classes can be."

When asked about what specific MSA lessons were appealing to their students, the teachers provided a wide variety of responses. Gary's students loved the activity where they load-tested beams, stud walls, and rafters. Kate said her students loved the activity where her students got to work with industry representatives. John thought his robotics lesson which encompassed coding exercises was successful because he had an engineering-minded student who was proficient in g-coding. John also perceived the tractor pull exercise to be well-received by his students. His students liked the activity so much they exceeded the expectations of the lesson by re-engineering their robotic tractor in attempt to pull a 50-pound load.

The teachers felt the CASE MSA curriculum helped their students become autonomous and bolstered their ability to solve problems. Sue offered, "[w]hen we were doing those [structural] beams, the fundamental parts on the structural systems weren't working out. I didn't have anything printed out to help them with pitfalls, so they had to just figure it out on their own." Sue noted, "[w]hile they were frustrated, they could peer-teach and figure it out and share with others. It was a blessing to have to have them figure it out on their own."

Kate explained when she assigned CASE MSA curriculum group work, her students would work on their own and get back with their partners afterwards to compare results. She felt the CASE MSA curriculum made them want to engage in problem-based activities on their own. Kate indicated her belief that CASE taught them to problem-solve and not just rely on their peers to do the work for them. With a similar sentiment to Kate, Sue noted she had seen a confidence boost in female students in her course. Sue said she usually paired up males and females so each group would have a person with some background in mechanics when working with small gas engines. Her female students gained confidence in her CASE MSA-focused course and felt they didn't need their male peers' assistance. She feels all her students have benefited because the curriculum forces them to engage in the learning process and doesn't let them sit back and watch.

Aside from benefits expressed for female students, Sue and Julie noted the CASE MSA curriculum has contributed to the success of students with learning disabilities. Sue stated, the curriculum has "allowed some of my students who are not highlighted in academic area, they shine in here because they figure out some processes where they might not in other classes." Julie indicated this curriculum improved the problem-solving abilities of students with special needs. When reflecting on a student who struggled with literacy issues, she said, "[h]e came in on the make-up day and had his engine working in five minutes. He stayed till noon to help other students get their engine to work."

Another student success associated with the new curriculum was the learning and benefits of mastering the content extended well beyond the walls of the SBAE program. For example, Kate felt the engineering reports the students completed in the CASE MSA curriculum have helped students complete lab reports in other courses, such as chemistry and biology. She also reported her students' writing and math skills have improved based on the industry-based applications provided by the CASE MSA curriculum. Outside of benefits associated with coursework, Paul and Sue provided examples of their students using CASE MSA-inspired projects as entries for local and state science fairs. Paul said he had students in the SBAE program and students in his student enrichment course who decided to develop science fair projects based on their experience with the 3D printer. Sue noted she had one student who is conducting research on the impact of different octanes of gasoline on engine efficiency and duration of use. Two of Sue's students are conducting research on load testing of trusses and beams based on activates provided in the CASE MSA curriculum. Sue liked how what they covered in her course was expanded to industry-based applications.

Challenges

The SBAE teachers felt the innovative, student-centered learning approach of the CASE MSA curriculum also served as a challenge for their students who were accustomed to teacher-centered learning. According to Paul, his students didn't know how to handle the "student-driven side of the CASE [MSA] curriculum." Paul insisted his students want him to tell them what he wants from them and that they don't like the open-ended style of learning. Paul explained the solution to this problem is to figure out the "balance and giving that control to the students has been difficult for me." Similar to Paul, Sue's students found it was challenging to follow the detailed instructions provided by CASE. To remedy this issue, she tries to have the students read the instructions out loud in a group setting and focus on the most vital points.

Kate sensed some frustration from her students regarding the student-centered learning encompassed in the CASE MSA curriculum. She stated students who had previously taken a CASE-based course had an idea of what to expect but "phasing a new student into the [CASE] MSA course was difficult." She insisted the small gas engines portion of the curriculum needs to provide more background information because it just leaves it up to the students to figure out the instructions on their own. As the facilitator in student-centered learning activities, Kate believes it is important to make sure students have background information on what they will be doing so her students will be able to be successful. Kate stated, "[d]uring the engineering part, the students didn't do very well because they didn't think though the concepts before getting to the report."

The students in the CASE MSA-focused courses also thought the curriculum was too rigorous and overwhelming. John explained, "[i]t's tough. If students don't think they will be good at it, they give up right away." While John agreed using the CASE MSA curriculum enhanced the rigor of the agricultural mechanics component of his program, he believed some student resistance was a product of the culture of his department. Specifically, students complained about having to engage in intensive writing assignments and became resentful because the writing expectations are greater than those in other agricultural courses.

Conclusions, Discussion, and Recommendations

Following the three key components of Rogers' (2003) diffusion of innovations theory (i.e., the concept of social systems, the idea of compatibility of innovative ideas, and the categorization of early adopters), we found the CASE MSA curriculum can serve as an innovation that lends itself to adoption. The compatibility of combining agricultural mechanics subject matter with real-world, problem-based learning in the classroom was seen to be innovative and adoptable by participants. Participants identified a primary social system of learning with the students and approaching the CASE MSA curriculum lesson-to-lesson as a positive towards adoption. The teachers who were early adopters modified the curriculum as needed to reach the educational goals of their agricultural mechanics courses. These modifications primarily focused around challenges faced with equipment and material costs.

By virtue of the field test status of the CASE MSA curriculum, the teachers in our study are considered early adopters per Rogers (2003). This trend of early adoption was indicated by the teachers' CASE certifications prior to undertaking the CASE MSA curriculum. Interestingly, while these teachers expressed a willingness to attempt something new within their agricultural mechanics courses, there were some lingering questions about their future use of the CASE MSA curriculum. Hesitations to re-use the CASE MSA curriculum were expressed along with others' plans to continue adapting the curriculum to identify the most appropriate fit into their agricultural mechanics courses. As such, these teachers can be considered to be in the *Decision*, *Implementation*, and *Confirmation* stages of Rogers' (2003) model of the five stages in the innovation-decision process.

The challenges these teachers expressed (e.g., students' reluctance to engage, cost of materials, etc.) were consistent with other studies that focused on the use of CASE in SBAE settings (Lambert et al., 2014; Wells et al., 2019). Particular to the CASE MSA curriculum, however, the tailoring of the small gas engines unit was so particular that teachers who did not have the small gas engines originally used in the CASE MSA curriculum materials were forced to augment their curricula and adjust the depth of the CASE MSA experience for their students. We recommend this issue be addressed by modifying CASE MSA content to be adaptable to other small gas engine types and sizes.

Regarding research, we recommend additional studies be undertaken to further explore the use of the CASE MSA curriculum within SBAE programs. These studies should be qualitative and quantitative in nature and should focus on factors specific to teachers, such as deeper exploration into challenges associated with the CASE MSA curriculum and how teachers overcome adversity and become resilient when trying something new. Qualitative and quantitative studies should also examine factors related to students, such as academic and technical subject matter knowledge retention over time, cognitive engagement in CASE MSA curriculum activities, and perspectives on learning STEM applied through agricultural mechanics courses. Moreover, additional research addressing how employing the CASE MSA curriculum within SBAE programs over time impacts stakeholders' perceptions of agricultural mechanics courses would be useful as well. Greater understanding of each of these topics will yield insight into how future CASE MSA curriculum deployment should occur and could help develop a framework for studying other CASE curricula.

We further recommend CASE MSA stakeholders collaborate to continuously modify the CASE MSA curriculum to reflect the changing needs of teachers and students. The teachers in our study were, for the most part, positive about the opportunity to continue using the CASE MSA curriculum as a method to advance the scientific focus of their agricultural mechanics courses, thereby helping to drive home innovation within their program structures. The CASE MSA curriculum has potential to help further mold the agricultural mechanics instructional philosophies of these teachers. Further refinement of the CASE MSA curriculum could have profound impacts for future adoption by others. Robinson et al. (2018) noted SBAE teachers could positively contribute to STEM education. Innovations begin within the initial step of recognizing that making changes to current practices can create lasting benefits for the future (Rogers, 2003).

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