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A Regional Study of the Agricultural Mechanics Knowledge and Skills Needed by School-based Agricultural Education Teachers

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Abstract

A priority of agricultural teacher education programs is to develop technically competent, prepared school-based agricultural education (SBAE) teachers. SBAE teachers should be knowledgeable in various agricultural subject matter, such as agricultural mechanics. Using Roberts and Ball's (2009) Content-based Model for Teaching Agriculture as the conceptual framework for our study, we used a three-round Delphi technique to identify the agricultural mechanics knowledge and skills SBAE teachers in Arkansas, Louisiana, Oklahoma, and Texas need to successfully teach agricultural mechanics courses. Spread across all four states, a panel of 47 SBAE teachers with expertise in agricultural mechanics contributed data for our study. Thirty-five teachers participated in all three rounds. After all three rounds were completed, 71 technical agricultural mechanics knowledge and skill items (e.g., circular saw use, computer numerical control [CNC] systems use, etc.) and 49 agricultural mechanics "teacher skill" / laboratory management knowledge and skill items (e.g., budget management, developing a student traffic control system, etc.) were identified. We recommend various efforts to help expand teachers' competence in these items should be undertaken within these states, including: (1) establishing and expanding partnerships with agricultural industry stakeholders to provide professional development opportunities for SBAE teachers, (2) realigning agricultural teacher education courses and experiences to better reflect teachers' agricultural mechanics knowledge and skill needs, and (3) facilitating opportunities for teachers to develop competence in agricultural mechanics through SBAE teacher-led training. To help provide systematic, consistent examination of teacher competence needs in agricultural mechanics, replication of our study should occur at regular intervals.

Keywords: school-based agricultural education; agricultural mechanics; knowledge; skills

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Introduction

School-based agricultural education (SBAE) programs serve a variety of functions, such as engaging students in leadership activities (Phipps et al., 2008), preparing students for careers in the agricultural industry (Stripling & Ricketts, 2016), and providing practical applications of academic knowledge (Haynes et al., 2012; Parr et al., 2006; Young et al., 2009). SBAE programs are intended to be led by qualified, effective SBAE teachers (Easterly & Myers, 2017; Phipps et al., 2008). Effective SBAE teachers are necessary components of quality SBAE programs (Easterly & Myers, 2017) who display a variety of characteristics (Eck et al., 2019; Roberts & Dyer, 2004), including dedication, pedagogical knowledge, and knowledge about agriculture. Knowledge about agricultural subject matter has been consistently identified as a trait of effective SBAE teachers (Eck et al., 2019; Roberts & Dyer, 2004; Whittington, 2005).

SBAE teachers can be developed into capable, effective, and knowledgeable professionals through multiple approaches. At the pre-service level, agricultural teacher education programs are tasked with developing teacher candidates to implement quality SBAE programming (Myers & Dyer, 2004; Roberts & Dyer, 2004; Whittington, 2005). Agricultural teacher education programs should provide opportunities for agricultural subject matter knowledge and skill development through a variety of methods, including early field experiences (Wells et al., 2018), technical agricultural courses (Hainline & Wells, 2019; Whittington, 2005), and student teaching experiences (Wells et al., 2019; Whittington, 2005) to help prepare teacher candidates for the realities of teaching and learning in SBAE settings. Agricultural teacher educators must consider the depth and breadth of agricultural subject matter knowledge needed by beginning teachers within the scope and structure of agricultural teacher education programming (Roberts & Kitchel, 2010). To provide the best foundation for pre-service SBAE teachers entering the profession, agricultural teacher education programs must offer opportunities to develop their knowledge and skills in agricultural subject matter (Whittington, 2005).

In 2015, The National Council for Agricultural Education established content standards in eight career pathways. These career pathways include: (1) Power, Structural and Technical Systems, (2) Plant Systems, (3) Natural Resource Systems, (4) Food Products and Processing Systems, (5) Environmental Service Systems, (6) Biotechnology Systems, (7) Animal Systems, and (8) Agribusiness Systems. Among the career pathways, Power, Structural, and Technical Systems (i.e., agricultural mechanics) is a common pathway in many SBAE programs in which teachers should be prepared to teach safely and effectively (Hainline & Wells, 2019; Saucier et al., 2014). Agricultural mechanics courses are popular choices for many students (Valdez & Johnson, 2020) and includes a vast array of subject matter that may be taught in any individual SBAE program (Burris et al., 2005; Hainline & Wells, 2019; McCubbins et al., 2016; McCubbins et al., 2017; Wells et al., 2013). Teachers may be faced with teaching metalworking, welding, biofuels, alternative energy systems, structures, woodworking, power mechanics, electricity, and more within agricultural mechanics courses and laboratories (Hainline & Wells, 2019). SBAE teachers need agricultural subject matter expertise to effectively teach topics relevant to industry and to better serve students over the long term (Albritton & Roberts, 2020; Easterly & Myers, 2017; Eck et al., 2019; Hainline & Wells, 2019; Roberts & Ball, 2009).

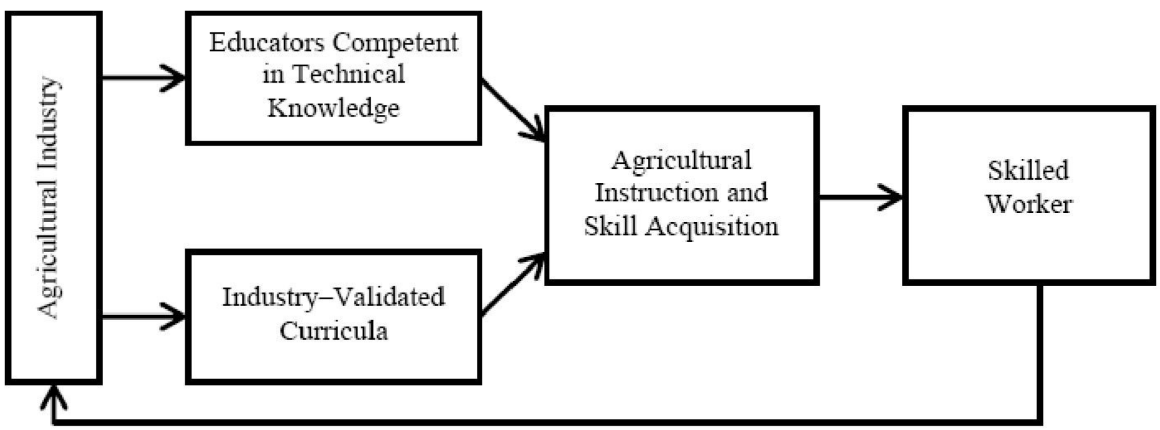
Pre-service (Tummons et al., 2017) and in-service SBAE teachers (Burris et al., 2010) often feel under-prepared to teach agricultural mechanics courses. Such feelings can encompass numerous factors, such as the liability issues present when teaching laboratory-based courses (Hainline et al., 2019), concerns about teachers' own competence to teach agricultural mechanics courses (Tummons et al., 2017), and lack of belief in their own abilities to perform technical agricultural mechanics tasks, such as welding (Blackburn et al., 2015). Understanding these feelings and concerns are important, as prior research (Zirkle & Barnes, 2011) has indicated teachers may simply forego working in laboratory settings altogether, particularly if fear of accidents, liability issues, and so forth overshadow perceived benefits of carrying out instructional opportunities. Thus, it is conceivable to postulate that if SBAE teachers perceive themselves to be limited in their ability or competence to teach agricultural mechanics courses, instruction in the subject matter may be avoided, thereby inhibiting student learning and limiting the potential impact of SBAE programming on students and local communities. Defining a pathway forward to help focus and improve teacher competence in agricultural mechanics is paramount to ensure teachers are as effective as possible.

Effective SBAE teachers actively pursue learning opportunities to improve their abilities as education professionals (Roberts & Dyer, 2004). Opportunities to learn and practice relevant knowledge and skills will help teachers develop a degree of competence in agricultural subject matter (Whittington, 2005). As Tummons et al. (2017) suggested, concerns about teaching agricultural mechanics courses, especially regarding technical subject matter knowledge needs and abilities, do indeed exist. Defining specific knowledge and skills necessary to provide high-quality, engaging, safe, and effective educational experiences in agricultural mechanics would be useful as SBAE stakeholders (e.g., agricultural teacher educators, state-level agricultural education / FFA staff members, etc.) tackle the challenge of improving teacher competence in technical agriculture subject matter.

Conceptual Framework

We used Roberts and Ball's (2009) Content-based Model for Teaching Agriculture (see Figure 1) as the conceptual framework for our study.

Figure 1
Content-based Model for Teaching Agriculture (Roberts & Ball, 2009)



While our study is part of a larger effort to address agricultural mechanics within SBAE programs, we focused on the *Educators Competent in Technical Knowledge* aspect of Roberts and Ball's (2009) model. SBAE teachers are tasked with helping to prepare the next generation of agricultural industry employees and leaders (Stripling & Ricketts, 2016). As such, SBAE teachers must be prepared to deliver learning experiences that actively engage students (Phipps et al., 2008; Talbert et al., 2014). Roberts and Ball (2009) described their model as follows:

> It begins with the agricultural industry, which provides the basis for the curricula taught and for teacher preparation. In turn, teachers utilize the curricula to provide industry-relevant instruction that results in observable skill acquisition. The end result is skilled workers that are ready for successful employment in the agricultural industry. (p. 84)

Roberts and Ball (2009) noted while SBAE is transitioning toward into a contextually-driven entity, a content-focused model "[is] relevant and appropriate for contemporary agricultural education" (p. 86). The agricultural industry plays a key role in the purposes and functions of SBAE (Doerfert, 2011; Stripling & Ricketts, 2016). Thus, SBAE teachers are agricultural industry stakeholders who have the significant purpose of helping prepare subsequent generations of stakeholders. Due to this role, SBAE teachers should have a degree of expertise in knowledge and skills relevant to agriculture (Whittington, 2005). As noted by Easterly and Myers (2017), knowledgeable and skilled teachers are essential assets of quality SBAE programs.

Agricultural subject matter expertise is a trait of effective SBAE teachers (Eck et al., 2019; Roberts & Dyer, 2004). Teachers help prepare their students to pursue opportunities beyond the classroom (Stringfield & Stone, 2017). In the context of agricultural mechanics, teachers must be prepared to provide their students with learning opportunities that reflect current practices used within the agricultural industry (Hainline & Wells, 2019; McCubbins et al., 2017). To help ensure agricultural workforce needs in Arkansas, Louisiana, Oklahoma, and Texas are met, defining a list of specific agricultural mechanics knowledge and skill items SBAE teachers in these states need is important. Doing so will result in several useful, tangible products, including: (1) providing pre-service and in-service SBAE teachers with a specified list of agricultural mechanics knowledge and skill items to help them self-identify current competencies and deficiencies, (2) expanding conversations and partnership efforts with agricultural industry stakeholders in these states to continue defining and addressing teachers' agricultural mechanics knowledge and skill needs, and (3) granting agricultural teacher educators and agricultural teacher education programs with a data-driven, peer-reviewed resource to help steer the direction of agricultural mechanics preparation for pre-service SBAE teachers. While our study was focused on experienced SBAE teachers' perceptions of the agricultural mechanics knowledge and skill items teachers need competence in, we intended to provide a springboard for future efforts related to improving teachers' competence to teach agricultural mechanics courses.

Purpose and Objectives

The purpose of our study was to describe the agricultural mechanics knowledge and skills SBAE teachers in Arkansas, Louisiana, Oklahoma, and Texas need to successfully teach agricultural mechanics courses. We purposefully selected these four adjoining states for inclusion within our study due to: (1) the likelihood of pre-service SBAE teachers from these states to complete our respective agricultural teacher education programs, (2) the likelihood of our pre-service SBAE teachers to accept teaching positions within these four states, and (3) to guide the evolution of agricultural mechanics training for teachers completing agricultural teacher education programs in these four states. The perceptions of a panel of SBAE teachers with expertise in agricultural mechanics was used to accomplish our purpose. Our study was part of a larger, more comprehensive study designed to address agricultural mechanics within SBAE programs. Two research objectives guided our study:

1) Identify the technical agricultural mechanics knowledge and skills needed by SBAE teachers in Arkansas, Louisiana, Oklahoma, and Texas.

2) Identify the agricultural mechanics "teacher skills" / laboratory management knowledge and skills needed by SBAE teachers in Arkansas, Louisiana, Oklahoma, and Texas.

Our study aligns with Research Priority 3 of the American Association for Agricultural Education (AAAE) National Research Agenda (NRA): Sufficient Scientific and Professional Workforce that Addresses the Challenges of the 21st Century (Stripling & Ricketts, 2016). As one function of SBAE programs is to help prepare students to enter the agricultural industry workforce

(Phipps et al., 2008), SBAE teachers must be adequately prepared to help students do so (Stripling & Ricketts, 2016). Prior studies (Clemons et al., 2018; Figland et al., 2019; Smalley et al., 2019; Sorensen et al., 2014) have established SBAE teachers desire preparation for teaching agricultural mechanics courses. However, due to the breadth and depth of knowledge and skills related to different facets of agricultural mechanics, greater details about specific knowledge and skill sets are needed.

Methods

Using a panel of SBAE teachers with expertise in agricultural mechanics, we employed a three-round Delphi technique to develop consensus regarding the agricultural mechanics knowledge and skills SBAE teachers in Arkansas, Louisiana, Oklahoma, and Texas need to successfully teach agricultural mechanics courses. All recruitment and data collection procedures were conducted electronically via Qualtrics.

Participants

The panel members were selected via a nomination process. The nomination process employed a snowball sampling technique and was guided by established selection criteria: (1) the panel member must have at least 10 years of agricultural mechanics teaching experience and (2) the panel member has taught agricultural mechanics courses in at least seven of the last 10 years. We initiated the nomination process by soliticing state-level SBAE leaders (e.g., agricultural teacher educators, state-level agricultural education / FFA staff, etc.) in the four states via e-mail and asking them to identify SBAE teachers who met our selection criteria.

Within the first-round instrument, each nominated SBAE teacher was asked to self-verify if their agricultural mechanics teaching experience met the criteria for the study. The first-round instrument also provided a platform for the nominated SBAE teachers to nominate other SBAE teachers who they believed fit the minimum experience criteria for this study. At the conclusion of the nomination process, 47 SBAE teachers with expertise in agricultural mechanics agreed to participate in our study as panel members. To aid in the retention of panel members throughout all three rounds of our study, we offered each panel member a chance to win one of six $50 gift cards. Dillman et al. (2014) noted offering appropriate compensation to participants can help increase response rates. Each panel member was informed their name was entered into the gift card drawing one time per each round they participated in. Thus, each panel member's chances of winning one of the gift cards increased as a direct result of their engagement throughout the study's duration.

The panel members had an average of 19.83 (*SD* = 7.20) years of teaching experience and an average of 19.41 (*SD* = 7.15) years of teaching experience in their current state. When asked about their participation in agricultural mechanics-focused FFA Career Development Events (CDEs), 45 panel members reported training at least one agricultural mechanics-focused CDE team in the past five years. The panel members indicated their students participated in a wide range of agricultural mechanics-focused FFA CDEs (i.e., Agricultural Technology and Mechanical Systems CDE, Tractor Tech CDE, Electrical Systems CDE, Carpentry CDE, Small Engines CDE, and Welding CDE). Aside from CDE participation, 38 panel members noted students in their SBAE programs have exhibited projects at agricultural mechanics project shows at the local, regional, state, and / or national level.

Each panel member was also asked to identify experiences influencing their perceptions of which agricultural mechanics knowledge and skills are needed by SBAE teachers. Experiences with teaching agricultural mechanics coursework (*f* = 43, 91.48%), experiences working in the agricultural industry (*f* = 28, 59.57%), and attending professional development workshops (*f* = 28, 59.57%) were the three experiences the greatest number of panel members perceived to influence their views of the knowledge and skills needed to successfully teach agricultural mechanics courses (see Table 1).

Table 1
Experiences Influencing Panel Members' Perceptions of the Agricultural Mechanics Knowledge and Skills Needed by SBAE Teachers (n = 47)

Experience	*f* (%)
My experiences teaching agricultural mechanics coursework	43 (91.48)
My experiences working in the agricultural industry	28 (59.57)
Attendance at professional development workshop sessions	28 (59.57)
My experiences with FFA activities (e.g., the Agricultural Mechanics CDE, etc.)	26 (55.32)
Meetings with other agricultural education teachers outside of my program	25 (53.19)
My high school coursework when I was a student	22 (46.81)
Attendance at annual agricultural education teacher conference(s)	22 (46.81)
Meetings with industry representatives	21 (44.68)
My early field experiences / observations before student teaching	19 (40.43)
My teacher education program coursework	18 (38.30)
My experiences with student Supervised Agricultural Experience programs	17 (36.17)
Meetings with other agricultural education teachers within my program	17 (36.17)
My student teaching experience	16 (34.04)
Meetings with community members	16 (34.04)
Meetings with my former students	16 (34.04)
Meetings with my current students	15 (31.91)
Compliance with mandated course standards	14 (29.79)

Data Collection / Instrumentation

Three different Qualtrics-based instruments were used to establish consensus among the panel members throughout the three rounds of our study. Following the initial distribution of each Delphi instrument, two reminder emails were sent to the participants in seven-day increments. The first-round instrument was linked to the recruitment e-mail which provided information about the study and asked participants to sign an electronic informed consent form. The first-round instrument included demographic and background characteristic items (e.g., teaching experience, CDE team involvement, etc.), a request form to nominate other SBAE teachers the panel members believed met the initial selection criteria, and two open-ended questions:

> 1) What technical agricultural mechanics knowledge and skills are needed by agricultural education teachers to successfully teach agricultural mechanics courses in [STATE]?
>
> 2) What "teacher skills" / laboratory management knowledge and skills are needed by agricultural education teachers to successfully teach agricultural mechanics courses in [STATE]?

After round one responses were collected, 148 unique knowledge and skill items were identified by the panel members. Of the 148 items, 96 were technical agricultural mechanics knowledge and skill items and 52 were important "teacher skill" / laboratory management knowledge and skill items. The 148 items gathered from the first-round instrument were presented to the panel members within the second-round instrument. Each item was coupled with a six-point scale (1 = *Strongly disagree*, 2 = *Disagree*, 3 = *Slightly disagree*, 4 = *Slightly agree*, 5 = *Agree*, 6 = *Strongly agree*) which allowed each panel member to gauge their level of agreement with the perceived importance of each item. This six-point scale has previously been used in agricultural education research conducted via the

Delphi technique (i.e., Hainline & Wells, 2019; Ramsey & Edwards, 2011). The second-round instrument also included an open-ended item which prompted the panel members to include any other agricultural mechanics knowledge and skill items not presented on the second-round instrument.

The second-round instrument was sent only to the 47 panel members who provided feedback in the first-round Delphi instrument. Forty-one panel members completed the second-round Delphi instrument, accounting for a response rate of 87.23%. Congruent to consensus criteria utilized in prior agricultural education Delphi studies (Hainline et al., 2019; Lundry et al., 2015; Ramsey, 2009), at least 75% of the panel members must have either agreed or strongly agreed with the importance of an item for it to achieve consensus in the second round. The items on the second-round Delphi instrument rated as a five (*Agree*) or six (*Strongly agree*) by 51% to 74% of the panel members were re-evaluated on the third-round instrument. The items which failed to receive a rating of five or six by at least 51% of the panel members were excluded from further consideration.

On the third-round instrument, the panel members who provided input on the first two rounds of the Delphi process were asked to gauge their level of agreement with the perceived importance of each topic on a six-point scale (1 = *Strongly disagree*, 2 = *Disagree*, 3 = *Slightly disagree*, 4 = *Slightly agree*, 5 = *Agree*, 6 = *Strongly agree*). Similar to the second-round instrument, at least 75% of the panel members must have either agreed or strongly agreed with the perceived importance of an item for the item to achieve consensus in the third round. All third-round items which fell below this threshold were eliminated from further consideration. At the conclusion of data collection for round three, 35 (85.37% response rate) panel members completed the third-round instrument.

Validity and Reliability

The first-round instrument was reviewed by three agricultural teacher educators to ensure content validity and enhance its readability. The three members were intentionally selected based on their expertise and experience teaching agricultural mechanics courses at the secondary and university levels. Panel member one was an assistant professor at a regional university in a southern state. He currently teaches agricultural mechanics courses as part of his teaching appointment. Panel member two was an associate professor at a Midwestern land-grant university who taught agricultural mechanics courses at the secondary level and established agricultural mechanics courses at the university level. Panel member three was an associate professor at a regional university in a southern state. He currently teaches four different undergraduate courses related to agricultural systems management. Each agricultural teacher educator was asked to assess the appropriateness of the open-ended items and provide any suggestions to refine the instrument. All three deemed the items to be appropriate but we augmented wording of the items based on their suggestions.

Goodman (1987) posited the content validity of Delphi instruments were enhanced by selecting knowledgeable individuals who have a strong interest in the given content matter of the study. In the context of this Delphi study, the participants were carefully selected based on the aforementioned selection criteria—bolstering the content validity of our study. Moreover, the implementation of the three-round Delphi process served to increase the concurrent validity of the study (Hasson et al., 2000; Sharkey & Sharples, 2001; Walker & Selfe, 1996).

Regarding instrument reliability, Dalkey et al. (1972) indicated a reliability coefficient of 0.70 could be expected from a Delphi panel with 11 or more members, and a coefficient of 0.90 was expected from a Delphi study with 13 or more members. The number of participants in each round of this Delphi study (Round 1, n = 47; Round 2, n = 41; Round 3, n = 35) exceeded the participant size threshold presented by Dalkey et al. (1972), which implied the findings of our study were reliable.

Data Analysis

Data from the open-ended questions on the first-round Delphi instrument were analyzed by organizing the panel members' responses into categories and deleting duplicate responses. The demographic / background characteristic items on the first-round instrument and the frequencies and percentages of the scale items on the second- and third-round instruments were analyzed using the IBM® SPSS® (Version 25) data analysis software.

Results

Round One

The panel members initially provided 548 agricultural mechanics knowledge and skill items for consideration. Of these 548 items, 143 were technical agricultural mechanics knowledge and skill items while 405 were agricultural mechanics "teacher skill" / laboratory management knowledge and skill items. Duplicate responses were eliminated from the list, resulting in a total of 148 unique knowledge and skill items. The final list of items generated from the first-round instrument included 96 technical agricultural mechanics knowledge and skill items and 52 agricultural mechanics "teacher skill" / laboratory management knowledge and skill items.

Round Two

One-hundred and forty-eight items related to important agricultural mechanics knowledge and skills needed by SBAE teachers were presented back to the panel members in the second-round instrument. After the completion of the second round of our study, 118 knowledge and skill items were considered to have achieved consensus (i.e., 75% of the panel members either agreed or strongly agreed with the perceived importance of the item). Twenty-two items received a five (*Agree*) or six (*Strongly agree*) from 51% to 74% of the panel members and were thus presented in the third-round instrument. Eight items received less than 51% agreement and were excluded from further consideration.

Seventy items regarding technical agricultural mechanics knowledge and skills achieved consensus during the second round of data collection. All panel members either agreed or strongly agreed on 16 technical agricultural mechanics knowledge and skills. The majority of these 16 items pertained to using different types of tools and / or equipment. Nineteen items received a five (*Agree*) or six (*Strongly agree*) from 51% to 74% of the panel members and were thus presented in the third-round instrument. Seven items received less than 51% agreement and were excluded from further consideration (see Table 2). It should be noted some items were skipped by at least one panel member during the questionnaire completion process. Thus, the percentage of agreement with these items was adjusted to correspond with the number of panel members who answered these items. These items are marked in both Table 2 and Table 3.

Table 2
Round Two and Three Findings: Technical Agricultural Mechanics Knowledge and Skills Needed by SBAE Teachers

Agricultural Mechanics Item	*n*	Category	% Agreement
Personal protective equipment (PPE) identification and use[a]	41	General Agricultural Mechanics	100.0
Estimating materials[a]	41	Layout and Measurement	100.0
Tape measure use[a]	41	Layout and Measurement	100.0
Drill press use[a]	41	Carpentry / Woodworking	100.0

Table 2
Round Two and Three Findings: Technical Agricultural Mechanics Knowledge and Skills Needed by SBAE Teachers, Continued…

Circular saw use[a]	41	Carpentry / Woodworking	100.0
Wood fastener (ex. screws, nails, glue) use[a]	41	Carpentry / Woodworking	100.0
Hand tool (ex. screwdriver, hammer, pliers) use[a]	41	Carpentry / Woodworking	100.0
Power tool (ex. cordless drill, impact wrench) use[a]	41	Carpentry / Woodworking	100.0
Wrench and socket use[a]	41	Engines and Machinery	100.0
Gas metal arc welding (GMAW [MIG welding])[a]	41	Metal Fabrication	100.0
Oxy-fuel cutting[a]	41	Metal Fabrication	100.0
Understanding welding principles (ex. joint types, welding positions)[a]	41	Metal Fabrication	100.0
Angle grinder use[a]	41	Metalworking	100.0
Bench grinder use[a]	41	Metalworking	100.0
Using tools in welding (ex. grinders, chipping hammers, wire brushes, etc.)[a]	41	Metalworking	100.0
Speed square use[a,c]	40	Layout and Measurement	100.0
Laying out a project[a]	41	Layout and Measurement	97.6
Band saw use[a]	41	Carpentry / Woodworking	97.6
Table saw use[a]	41	Carpentry / Woodworking	97.6
Jig saw use[a]	41	Carpentry / Woodworking	97.6
Reciprocating saw use[a]	41	Carpentry / Woodworking	97.6
Knowledge of types of saw blades and their uses[a]	41	Carpentry / Woodworking	97.6
Reading blueprints[a]	41	Construction and Manufacturing	97.6
Equipment maintenance[a]	41	Construction and Manufacturing	97.6
Wiring outlets[a]	41	Electrical Systems	97.6
Shielded metal arc welding (SMAW [Arc welding])[a]	41	Metal Fabrication	97.6
Chop saw use[a]	41	Metalworking	97.6
Tool identification[b,c]	34	General Agricultural Mechanics	97.0
Miter saw use[a]	41	Carpentry / Woodworking	95.1
Pneumatic (air) tool use[a]	41	Carpentry / Woodworking	95.1
Painting and finishing projects[a]	41	Construction and Manufacturing	95.1
Wiring trailer electrical systems[a]	41	Electrical Systems	95.1
Wiring single-pole switch circuits[a]	41	Electrical Systems	95.1
Plasma arc cutting processes[a]	41	Metal Fabrication	95.1
Structural welding techniques[a]	41	Metal Fabrication	95.1
Using measurement and marking tools (ex. calipers, micrometers, transits, fill gauges)[a]	41	Layout and Measurement	92.7

Table 2
Round Two and Three Findings: Technical Agricultural Mechanics Knowledge and Skills Needed by SBAE Teachers, Continued…

Wiring double-pole switch circuits[a]	41	Electrical Systems	92.7
Ability to look at a picture and build the project	41	Layout and Measurement	90.2
Building large projects (ex. trailers, barbecue pits)[a]	41	Construction and Manufacturing	90.2
Performing safe tractor operation procedures (ex. driving, attaching equipment)[a]	41	Engines and Machinery	90.2
Center punch use[a]	41	Metalworking	90.2
Using polyvinyl chloride (PVC) pipe[a,c]	40	Plumbing Systems	90.0
Drawing plans to scale[a]	41	Layout and Measurement	87.8
Technical manual use[a]	41	Layout and Measurement	87.8
Designing projects from scratch[a]	41	Layout and Measurement	87.8
Understanding the principles of electrical theory (ex. conductors, insulators, alternating current [AC], direct current [DC])[a]	41	Electrical Systems	87.8
Electrical systems tool (ex. multimeter, voltmeter, wire strippers) use[a]	41	Electrical Systems	87.8
Wiring three-way switch circuits[a]	41	Electrical Systems	87.8
Understanding the principles of four-stroke engine operational theory[a]	41	Engines and Machinery	87.8
Understanding the principles of two-stroke engine operational theory[a]	41	Engines and Machinery	87.8
Cold saw use[a]	41	Metalworking	87.8
Wood building construction[a]	41	Construction and Manufacturing	85.4
American Welding Society (AWS) standards for welding practices[a]	41	Metal Fabrication	85.4
Flux-core arc welding (FCAW)[a]	41	Metal Fabrication	85.4
Using appropriate plumbing fittings[a,c]	40	Plumbing Systems	85.0
Understanding units of electrical measurement (ex. amperes, volts, Ohms)[a]	41	Electrical Systems	82.9
Understanding principles of metallurgy (ex. identifying metals, use of metals)[a]	41	Metalworking	82.9
Fence construction[a]	41	Construction and Manufacturing	80.5
Building forms for concrete projects[a]	41	Construction and Manufacturing	80.5
Tap and die use[a]	41	Metalworking	80.5
Understanding the principles of diesel engine operational theory[a]	41	Engines and Machinery	80.5
Hydraulics systems and tool (ex. shears and punch presses) use[a]	41	Construction and Manufacturing	78.1

Table 2
Round Two and Three Findings: Technical Agricultural Mechanics Knowledge and Skills Needed by SBAE Teachers, Continued…

Estimating material needs for concrete projects[a]	41	Construction and Manufacturing	78.1
Powertrain theory and application[a]	41	Engines and Machinery	78.1
Using cross-linked polyethylene (PEX) pipe[a,c]	40	Plumbing Systems	77.5
Metal building construction[a]	41	Construction and Manufacturing	75.6
Mixing, placing, and finishing concrete projects[a]	41	Construction and Manufacturing	75.6
Wiring four-way switch circuits[a]	41	Electrical Systems	75.6
Gas tungsten arc welding (GTAW [TIG welding])[a]	41	Metal Fabrication	75.6
Iron worker use[a]	41	Metalworking	75.6
Computer numerical control (CNC) systems use[a]	41	Metalworking	75.6

Note. [a]Item reached consensus in round two; [b]Item reached consensus in round three; [c]Item was not answered by all panel members. 1 = *Strongly disagree*, 2 = *Disagree*, 3 = *Slightly disagree*, 4 = *Slightly agree*, 5 = *Agree*, 6 = *Strongly agree*.

The second-round instrument included 48 items focused on the agricultural mechanics "teacher skills" / laboratory management knowledge and skills needed by SBAE teachers. Based on the panel members' responses in the second round, 45 agricultural mechanics "teacher skill" / laboratory management knowledge and skill items achieved consensus. All panel members either agreed or strongly agreed on 11 agricultural mechanics "teacher skills" / laboratory management knowledge and skills. Three items associated with agricultural mechanics "teacher skills" / laboratory management knowledge and skills were incorporated into the third-round instrument for reconsideration. One item received less than 51% agreement and was excluded from further consideration (see Table 3).

Table 3
Round Two and Three Findings: Agricultural Mechanics "Teacher Skills" / Laboratory Management Skills Needed by SBAE Teachers

Agricultural Mechanics "Teacher Skill" / Laboratory Management Item	*n*	% Agreement
Making sure safety equipment and PPE are available[a]	41	100.0
Adjusting equipment based on performance needs[a]	41	100.0
Implementing laboratory clean-up procedures (delegation of clean-up duties)[a]	41	100.0
Emphasizing how acquired skills can be leveraged to career aspirations[a]	41	100.0
Checking for leaks on oxy-fuel systems[a]	41	100.0
Proper storage of oxy-fuel / welding tanks (i.e., using chains or cage)[a]	41	100.0
Proper transportation of oxy-fuel / welding tanks[a]	41	100.0
Changing blades on tools and equipment[a]	40	100.0
Changing out consumable parts in all equipment[a]	40	100.0
Implementing routine maintenance schedules for tools and equipment[a]	40	100.0
Proper supervision of students in the laboratory[a]	40	100.0
Organizing materials storage[a]	41	97.6
Repairing tools and equipment[a]	41	97.6

Table 3
Round Two and Three Findings: Agricultural Mechanics "Teacher Skills" / Laboratory Management Skills Needed by SBAE Teachers, Continued…

Improvisation while teaching[a]	41	97.6
The ability to justify money spent towards an agricultural mechanics program[a]	41	97.6
Procurement of laboratory materials, equipment, and consumables[a]	41	97.6
Performing first aid procedures[a]	41	97.6
Performing set-up procedures for new welders (ex. SMAW, GMAW, FCAW, GTAW)[a]	41	97.6
Knowing when to replace welding consumables[a]	41	97.6
Setting up regulators on fuel tanks[a]	41	97.6
Cleaning oxy-fuel torch tips[a]	41	97.6
Changing oxy-fuel tip types and attachments[a]	41	97.6
Teaching / enforcing laboratory safety procedures (ex. proper use of equipment)[a]	40	97.5
Developing a tool management system[a]	41	95.1
Implementing organization and storage practices[a]	41	95.1
Budget management[a]	41	95.1
Maintaining SawStop safety systems[a]	41	95.1
Implementing project management procedures[a]	41	95.1
Grading students' laboratory assignments[a]	41	95.1
Understanding the needs and dynamics of your students[a]	41	95.1
Changing gas / fuel tanks on welders and oxy-fuel system systems[a]	41	95.1
Installation of flashback arrestors on oxy-fuel systems[a]	41	95.1
Maintaining eye wash station[a]	41	92.7
Defining a list of five absolute safety rules and expectations[a]	41	92.7
Troubleshooting issues on equipment (ex. plasma-cutting system, hydraulic shear)[a]	40	92.5
Creating student "buy-in" to enhance facility safety[a]	41	90.2
Conducting risk / hazard analysis for laboratory and equipment[a]	41	90.2
Oxy-fuel and welding system hose repair[a]	41	90.2
Consulting with community members for collaboration[a]	41	85.4
Repairing other agricultural education program facilities (ex. greenhouses)[a]	41	85.4
Performing fire control and suppression techniques[a]	41	87.8
Being able to teach the "3-4-5 rule" for right angles[a]	41	87.8
Bleeding oxy-fuel / welding leads and regulators after use[a]	41	87.8
Maintaining lighting and ventilation systems[a]	41	85.4
Safety color-coding use[a]	41	85.4
Developing a student traffic control system[a]	41	82.9
Performing pneumatic system installation and maintenance procedures[a]	41	80.5
Sharpening chisels[a]	40	80.0
Repairing electrical components on equipment[b]	35	80.0

Note. [a]Item reached consensus in round two; [b]Item reached consensus in round three; [c]Item was not answered by all panel members. 1 = *Strongly disagree*, 2 = *Disagree*, 3 = *Slightly disagree*, 4 = *Slightly agree*, 5 = *Agree*, 6 = *Strongly agree*.

Round Three

The third-round instrument contained 22 items. Nineteen items addressed technical agricultural mechanics knowledge and skills. These items were: (1) *Tool identification*, (2) *Understanding OSHA regulations and industry codes*, (3) *Computer-aided drafting (CAD) design skills (ex. AutoDesk Inventor, Solidworks, Torchmate, SketchUp, VCarve)*, (4) *Global positioning system (GPS) use*, (5) *Surveying: Using a transit and GPS / laser equipment*, (6) *Radial arm saw use*, (7) *Dust collection systems use*, (8) *Plumbing system layout*, (9) *Using copper pipe*, (10) *Pipe threading equipment use*, (11) *Irrigation system design, installation, and use*, (12) *Electrical motors and controls use*, (13) *Understanding the principles of tractor systems (ex. steering control, braking, safety systems)*, (14) *Understanding the principles of emission systems and controls*, (15) *Understanding the principles of alternative fuel systems*, (16) *Oxy-fuel welding*, (17) *Brazing using a gas torch*, (18) *Soldering*, and (19) *Performing sheet metal work*.

Three items pertained to agricultural mechanics “teacher skills” / laboratory management knowledge and skills. These items were: (1) *Repairing electrical components on equipment*, (2) *Sharpening drill bits*, and (3) *Training an agricultural mechanics-focused CDE team*. Between the 22 items presented within the third-round instrument, only two items, *Tool identification* and *Repairing electrical components on equipment*, achieved consensus. At the closure of the third round of our Delphi study, all items that did not achieve the consensus threshold were excluded from further consideration. In total, 120 items achieved consensus in our study. Of this total number of items, 71 items were technical agricultural mechanics knowledge and skills and 49 items were agricultural mechanics “teacher skills” / laboratory management knowledge and skills needed by SBAE teachers.

Conclusions, Discussion, and Recommendations

We identified a wide array of agricultural mechanics knowledge and skills SBAE teachers in Arkansas, Louisiana, Oklahoma, and Texas need to successfully teach agricultural mechanics courses. Consistent with Hainline and Wells’ (2019) study with Iowa SBAE teachers, we likewise found SBAE teachers in these four states need numerous technical agricultural mechanics knowledge and skills and “teacher skills” / laboratory management knowledge and skills to successfully teach agricultural mechanics courses. Moreover, the agricultural mechanics knowledge and skills identified within our study were quite congruent with agricultural mechanics topics discussed in other scholars’ (Albritton & Roberts, 2020; Burris et al., 2005; Hainline & Wells, 2019; McCubbins et al., 2017; Saucier et al., 2014; Wells et al., 2013) works.

The skills identified in our study should be considered and emphasized by SBAE stakeholders (e.g., agricultural teacher educators, state-level agricultural education / FFA staff members, etc.) in these four states during teacher competence development experiences, such as pre-service teacher education courses, professional development opportunities, and so forth. We do wish to caution, however, that our results are not generalizable beyond the four states within our study. To help overcome this limitation, this study should be replicated to better understand the agricultural mechanics knowledge and skills needed by teachers in other areas of the United States. Perhaps a national-level study would be appropriate and useful as well. Regular, deliberate replication of our study would also provide insight into changes regarding SBAE teachers’ agricultural mechanics knowledge and skill needs. As our study was part of a larger, more comprehensive study designed to address agricultural mechanics within SBAE programs, expanding future research efforts to include other SBAE stakeholders such as agricultural industry representatives would help provide a more complete depiction of how to better develop competent, prepared teachers of agricultural mechanics.

The panel of teachers in our study indicated the need for teachers of agricultural mechanics to be competent in numerous technical skills associated with the broad categories of construction and manufacturing, layout and measurement, carpentry / woodworking, metal fabrication, metalworking, electrical systems, general agricultural mechanics, plumbing systems, and engines and machinery. The panel in this study also reached consensus on numerous "teacher skills" / laboratory management skills related to the safety of students, organizational strategies, as well as evaluation of student work. It is reasonable to consider these "teacher skills" / laboratory management skills to be in the wheelhouse of agricultural teacher educators. According to Williams (1991), the agricultural education discipline can be described as the study of teaching and learning within the context of agriculture. We recommend agricultural teacher educators use time and resources at their disposal (e.g., early field experiences, targeted student teaching placements, etc.) to help pre-service SBAE teachers develop teaching and laboratory management skills while facilitating connections with industry to provide the necessary technical skills. We also recommend the data collected within our study be shared with pre-service and in-service SBAE teachers to grant them an additional resource to help them self-identify their technical agricultural subject matter expertise strengths, weaknesses, and needs. Doing so may help stimulate SBAE teachers' interest in broadening their knowledge and skill sets and aid in self-reflection and identification of deficiencies, which in turn could stimulate SBAE teachers' interest in agricultural mechanics professional development.

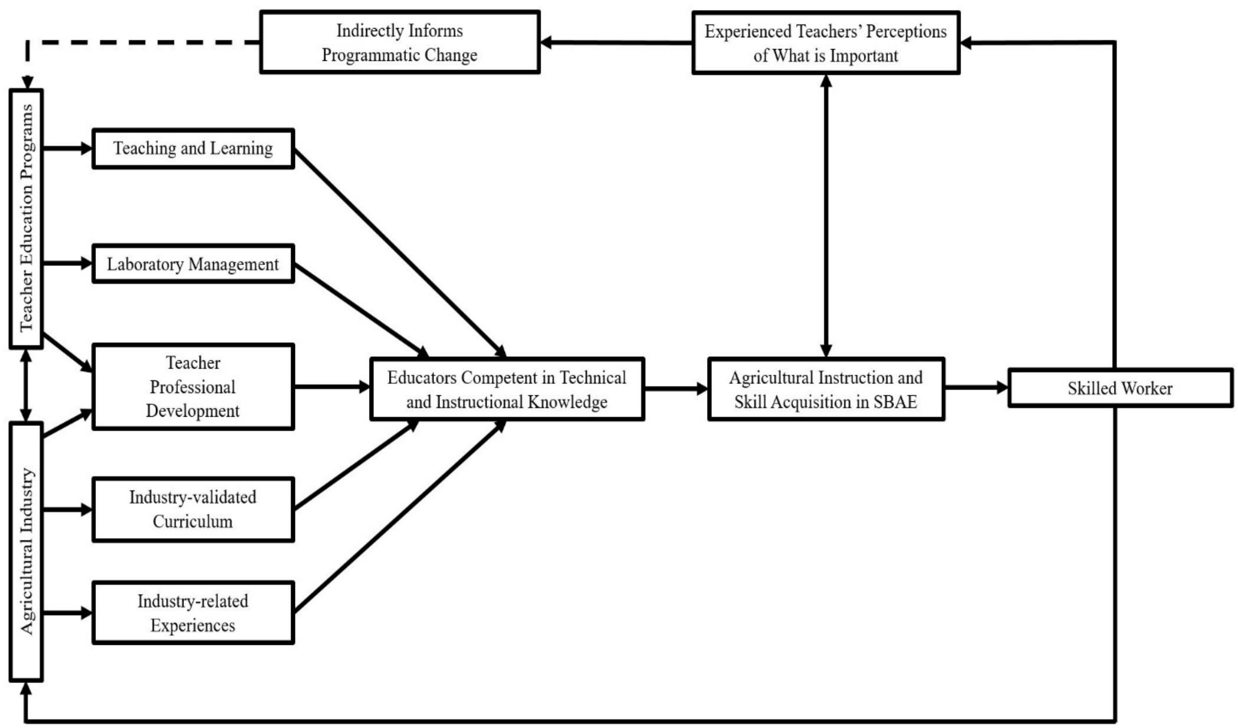
In our study, panel members were nominated by their peers in a snowball sampling method. Considering the nomination process, these panel members were considered by their peers as the most competent teachers of agricultural mechanics in their respective states. As part of the demographics section of our questionnaire, we asked each panel member to indicate their experiences influencing perceptions of the agricultural mechanics knowledge and skills needed by SBAE teachers. Interestingly, the top source of knowledge described by the panel was their experiences teaching agricultural mechanics coursework (f = 43, 91.48%), followed by their experiences working in the agricultural industry (f = 28, 59.57%) and attendance at professional development workshop conferences (f = 28, 59.57%). However, traditional agricultural teacher education as a source of knowledge ranked considerably lower. The traditional agricultural teacher education responses included early field experiences / observations before student teaching (f = 19, 40.43%), teacher education coursework (f = 18, 40.43%), and their sudent teaching experience (f = 16, 34.04%). Notably, this panel ranked their high school coursework when they were students (f = 22, 46.81%) higher than any agricultural teacher education program components.

These data suggest agricultural teacher education programs are not adequately preparing pre-service SBAE teachers to be successful implementing the agricultural mechanics courses and that successful teachers of agricultural mechanics are gaining knowledge through their teaching experience and professional development. We as agricultural teacher educators must ensure we continue helping facilitate the development of effective teachers through high-quality professional development opportunities. However, we recommend agricultural teacher educators be more purposeful in how and to what extent agricultural mechanics instruction is included within agricultural teacher education curricula. Although agricultural teacher education programs are limited concerning the number of credit hours and graduation requirements, creative solutions can be employed to bolster instruction in agricultural mechanics (Burris et al., 2005). We recommend embedding agricultural mechanics subject matter within curriculum design and teaching methods courses as a context for lesson development. Additionally, we recommend purposeful field experience and student teaching placements with cooperating teachers who are confident and competent teachers of agricultural mechanics.

In light of the need for both technical skills and "teacher skills" / laboratory management skills, we propose a new model building upon Roberts and Ball's (2009) Content-based Model for Teaching

Agriculture to include the role of training in the context of teaching, learning, and management (see Figure 2).

Figure 2
The Agricultural Teacher Education and Agricultural Industry Partnership Model



The Agricultural Teacher Education and Agricultural Industry Partnership Model provides a framework for the development of SBAE teachers that purposefully includes training in teaching and learning, laboratory management, and technical knowledge while engaging with industry to ensure curricula and professional development are keeping pace with the ever-changing technical needs of the agricultural industry. We recommend additional research to identify how the proposed model can inform practice in agricultural teacher education. We also recommend further research to identify how and to what extent partnerships between agricultural teacher education programs and industry exist as well as how agricultural teacher educators and state-level agricultural education / FFA staff members can cultivate partnerships with industry.

Roberts and Ball (2009) indicated SBAE teachers should be competent in their agricultural subject matter knowledge, which is congruent with Eck et al.'s (2019) and Roberts and Dyer's (2004) findings. Easterly and Myers (2017) noted effective teachers are paramount for the operation of high-quality SBAE programs. As a component of developing competent, prepared teachers, designing appropriate curricula and educational experiences is complex and multi-faceted (Roberts & Kitchel, 2010), particularly considering degree plan limitations, budgetary concerns, and so forth. While agricultural teacher educators should be willing collaborators, they should not be the only individuals expected to shoulder the burden of ensuring SBAE teachers are technically competent. Several approaches should be considered, such as trainings at regularly-scheduled SBAE teacher conferences, professional development opportunities offered by industry (e.g., Briggs and Stratton instructor field schools, Lincoln Electric welding instructor workshops, etc.), SBAE teacher-led trainings at the local, regional, state, and / or national level(s), and so forth. Such approaches could be beneficial for introducing SBAE teachers to individuals who may be able to address their needs in a different manner than courses completed within agricultural teacher education programs.

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