Journal of Agricultural Education, 60(1), 59-79
https://doi.org/10.5032/jae.2019.01059

Identifying the Agricultural Mechanics Knowledge and Skills Needed by Iowa School-based Agricultural Education Teachers

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Abstract

A historical portion of many school-based agricultural education (SBAE) programs, agricultural mechanics remains popular in schools across the nation. As such, pre-service and in-service teachers should be prepared to effectively deliver agricultural mechanics instruction (Burris, Robinson, & Terry, 2005). Agricultural education researchers (McKim & Saucier, 2012; Pate, Warnick, & Meyers, 2012) have identified many laboratory management competencies and welding skills that teachers should have; however, few knowledge and skill areas in other components of agricultural mechanics (e.g., woodworking, electricity, etc.) have been identified. Through the lens of Roberts and Ball's (2009) content-based model for teaching agriculture, we used the Delphi technique to identify the agricultural mechanics knowledge and skills that Iowa SBAE teachers should possess to provide quality instruction. A panel of 10 expert Iowa SBAE teachers provided the data for the present study. After three rounds, a total of 85 items reached consensus, which included 35 technical skills (e.g., plasma cutting, etc.) and 49 "teacher skills"/laboratory management skills (e.g., ordering consumables). We concluded that SBAE stakeholders in Iowa should ensure that teachers are prepared to teach agricultural mechanics via coursework and professional development opportunities. We recommend that this study be replicated in other states.

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

Note: This paper is a product of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa. Project No. IOWO3813 and sponsored by Hatch Act and State of Iowa funds.

Introduction

Laboratory instruction is a fundamental tenet of school-based agricultural education (SBAE) (Franklin, 2008; Phipps, Osborne, Dyer, & Ball, 2008; Talbert, Vaughn, Croom, & Lee, 2014). As a portion of the three-component model of SBAE (National FFA Organization, 2015), laboratory instruction serves to connect abstract classroom content to real-world, hands-on applications. Laboratories can come in many forms (e.g., agricultural mechanics, nurseries, land, etc.), and they have historically functioned as an engaging and useful form of instruction within SBAE programs (Shoulders & Myers, 2012; Twenter & Edwards, 2017).

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Laboratories can be useful contexts through which experiential learning processes can take place (Shoulders, Blythe, & Myers, 2013). As a prominent laboratory environment commonly found within many SBAE programs (Phipps et al., 2008; Shoulders & Myers, 2012; Talbert et al., 2014), agricultural mechanics laboratories, as well as aligned instructional practices, can serve as a context through which to apply academic content (Parr, Edwards, & Leising, 2006, 2008, 2009; Young, Edwards, & Leising, 2009), to practice problem-solving skills (Blackburn & Robinson, 2016; Pate & Miller, 2011), to develop and facilitate projects that can have considerable economic impacts over time (Hanagriff, Rayfield, Briers, & Murphy, 2014), and to provide opportunities for students to develop and hone a wide range of skills (Phipps et al., 2008; Wells, Perry, Anderson, Shultz, & Paulsen, 2013).

Beyond solely the laboratory environment, agricultural mechanics as a content area is broad and diverse, encompassing woodworking, metalworking, welding, power mechanics, electricity, building construction, biofuels, alternative energies, applied mathematics, and more (Burris, Robinson, & Terry, 2005; McCubbins, Anderson, Paulsen, & Wells, 2016; McCubbins, Wells, Anderson, & Paulsen, 2017; Wells et al., 2013; Young et al., 2009). This breadth of content, in turn, dictates that teachers should be flexible and well-prepared to deliver a wide range of learning experiences related to agricultural mechanics (McCubbins et al., 2017). From a historical perspective, agricultural mechanics is a foundational instructional component of SBAE (Burris et al., 2005). In addition, SBAE teachers indicate that many agricultural mechanics knowledge and skill areas (e.g., welding safety, plasma cutting, etc.) are important for inclusion into SBAE curricula (Shultz, Anderson, Shultz, & Paulsen, 2014). Thus, it stands to reason that teachers should be prepared to conduct high-quality agricultural mechanics instruction within their individual SBAE programs.

Recent trends in SBAE indicate that curricula revisions are necessary to ensure that SBAE stakeholders such as teachers are up-to-date in their abilities to address current and future issues in the agricultural industry (Doerfert, 2011; Stripling & Ricketts, 2016). This is especially true regarding teacher preparation in agricultural mechanics (Burris et al., 2005). In prior decades, issues have risen regarding the shrinking amount of agricultural mechanics content that preservice teachers are exposed to (Burris et al., 2005; Hubert & Leising, 2000). As could be expected, this phenomenon could negatively impact teacher training and subsequent performance in this curriculum area (Burris et al., 2005). Whittington (2005) described that preservice teachers should receive the opportunity to develop a level of competency with various agricultural curricula. Agricultural mechanics is no exception to this. Further, as teacher preparation programs examine methods of streamlining, and often reducing, credit requirements for graduation purposes (Whittington, 2005), agricultural mechanics courses are often trimmed (Burris et al., 2005; Hubert & Leising, 2000).

As many SBAE programs have retained coursework in agricultural mechanics, teachers should be prepared to work safely and effectively in such environments to properly employ and maximize such resources (Saucier, Vincent, & Anderson, 2014). Pre-service teachers often feel challenged when stepping into the role of teaching agricultural mechanics content (Tummons, Langley, Reed, & Paul, 2017). This is reflected in early career teachers as well, as described by Burris, McLaughlin, McCulloch, Brashears, and Fraze (2010). Extensive research (Johnson & Schumacher, 1989; Johnson, Schumacher, & Stewart, 1990; McKim & Saucier, 2011a, 2011b, 2012, 2013; Saucier & McKim, 2011; Saucier, McKim, & Tummons, 2012; Saucier et al., 2014; Schumacher & Johnson, 1990) has been conducted to address in-service and pre-service teachers' laboratory management and safety education.

Outside the scope of agricultural mechanics laboratory management and safety, little work has been conducted recently to identify potential areas of improvement in preparing teachers to provide agricultural mechanics instruction. Pate, Warnick, and Meyers (2012), through the use of a Delphi technique, identified a variety of welding skills that early-career SBAE teachers should have, thus creating an itemized list that educational stakeholders can offer through coursework and professional development opportunities. Moreover, Blackburn, Robinson, and Field (2015) found that pre-service teachers often do not perceive themselves as being highly capable of competently demonstrating a variety of welding skills. Leiby, Robinson, and Key (2013) indicated that pre-service teachers believe that welding skills are important to teach.

Based on the preceding literature, welding appears to have been the agricultural mechanics content area most focused on in the last decade. But what of other areas of agricultural mechanics? Leiby et al. (2013), Blackburn et al. (2015), and Pate et al. (2012) recommended that other areas outside of welding (e.g., small gas engines, electricity, etc.) should be examined as well. Perhaps a more complete image of the agricultural mechanics knowledge and skill needs of both pre-service and in-service SBAE teachers would be of critical use to the agricultural education profession. As, such, we postulated that the conduct of such a study would provide a timely and needed examination of agricultural mechanics knowledge and skills needed by SBAE teachers. As agricultural mechanics content is diverse and popular at the secondary level (Burris et al., 2005; Shultz et al., 2014), SBAE teachers must be prepared via teacher preparation programming and professional development opportunities to engage in agricultural mechanics instruction. We believed that a defined list of specific knowledge and skill areas would be useful to this process.

Conceptual Framework

The conceptual framework that guided the present study was Roberts and Ball's (2009) content-based model for teaching agriculture (see Figure 1).

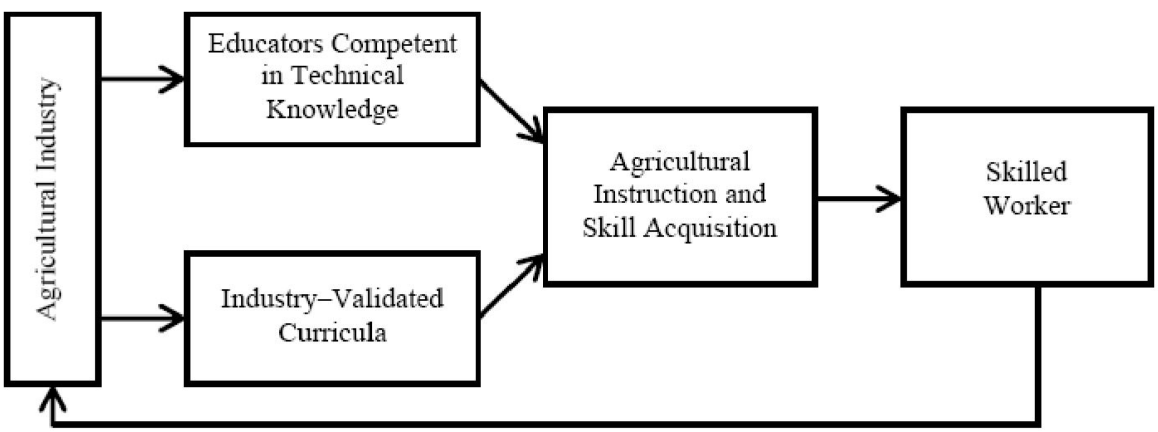

Figure 1. A content-based model for teaching agriculture (Used with permission).

Within the context of the present study, our focus was upon the *Educators Competent in Technical Knowledge* portion of this conceptual model and how as an individual component it may over time have a substantial impact on the agricultural industry. As SBAE teachers are responsible for helping to prepare the forthcoming generation of agricultural industry employees and employers, (Doerfert, 2011; Stripling & Ricketts, 2016), teachers should be well-prepared and competent to deliver quality learning experiences for students in SBAE programs (Phipps et al., 2008; Talbert et al., 2014). Roberts and Ball's (2009) model presented in Figure 1, based on much of the foundational components and literature related to SBAE and career and technical education (CTE) more broadly, is described 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)

While acknowledging that SBAE is continuing to transition into a contextually-driven entity, Roberts and Ball (2009) stated that as there have been many advances in SBAE since its formalization in 1917, a content-focused model "[is] relevant and appropriate for contemporary agricultural education" (p. 86). Industry continues to play a key role in the purpose of SBAE (Doerfert, 2011; Stripling & Ricketts, 2016) and SBAE teachers are stakeholders within the scope of the agricultural industry.

As stakeholders in industry, SBAE teachers, as a significant portion of the agricultural workforce development process, should be skilled and knowledgeable in their subject matter (Whittington, 2005). Skilled and knowledgeable teachers are an extraordinary asset in any SBAE program (Easterly & Myers, 2017). Expertise in subject matter is frequently cited as a characteristic of a high-quality, effective SBAE teacher (Roberts & Dyer, 2004). As teachers help to serve as the preparers of students for the world beyond the classroom (Stringfield & Stone, 2017), teachers must be adequately prepared to collaborate with industry and deliver content that is suited toward the goal of producing well-prepared agricultural industry employees and stakeholders (McCubbins et al., 2017). The allocation of proper resources (e.g., preparation and training in content knowledge and skills) to teachers is a must (McCubbins et al., 2016). If the agricultural industry is, in its current state, to remain viable over the long term, the issue of workforce development must be addressed (Stripling & Ricketts, 2016). As a part of the solution, SBAE teachers' expertise should be well-defined and, in the context of Iowa, relevant for the workforce of tomorrow.

Purpose and Objectives

The purpose of our study was to determine the agricultural mechanics content knowledge and technical skills mastery that Iowa SBAE teachers need to successfully provide and facilitate agricultural mechanics instruction at the secondary level, as determined by the perceptions of a panel of experts. The following two objectives guided this research study:

1. Identify the important agricultural mechanics knowledge and skills needed by Iowa SBAE teachers.
2. Determine the important agricultural mechanics "teacher skills"/laboratory management skills) needed by Iowa SBAE teachers.

This study aligns with Research Priority 3 of the National Research Agenda (NRA) of the American Association for Agricultural Education (AAAE): Sufficient Scientific and Professional Workforce that Addresses the Challenges of the 21st Century (Stripling & Ricketts, 2016). Because SBAE programs are tasked with helping to prepare the future agricultural industry workforce members (Phipps et al., 2008; Talbert et al., 2014), teachers bear responsibility for guiding the process. Teachers must be well-prepared in various content areas to help facilitate the preparation of the agricultural workforce (Stripling & Ricketts, 2016). Teacher preparation programs occupy a prominent role in ensuring that teachers are well-qualified (Whittington, 2005). As such, teacher preparation programs must be prepared to adapt and address pre-service and in-service teachers' needs through a variety of approaches (Whittington, 2005). However, in order to address issues related to content knowledge and skills, information is needed about what exactly those knowledge and skills should be.

Methods

A three-round Delphi technique was used to determine the important agricultural mechanics knowledge and skills (i.e., technical skills and "teacher skills"/laboratory management skills) needed by Iowa SBAE teachers. The Delphi process was used to identify the expert opinions of a group of experienced Iowa SBAE teachers who specialize in teaching agricultural mechanics. According to Hasson, Keeney, and McKenna (2000), the Delphi approach is a "group facilitation technique, which is an iterative multistage process, designed to transform opinion into group consensus" (p. 1008). Moreover, the Delphi method can serve as a valuable resource to inquire about problems which do not lend themselves to analytical techniques (Adler & Ziglio, 1996), or in instances when a lack of information is available regarding a given phenomenon or problem (Murphy et al., 1998; Skulmoski, Hartman, & Krahn, 2007).

Participants

The utility of the results gathered from a Delphi study rest on the aggregate expertise of the individuals which constitute the panel of experts (Hsu & Sandford, 2007; Powell, 2003). To ensure the qualification of experts, selection criteria were established *a priori* to guide the recruitment of experts. More specifically, the minimum qualifications included: (1) having at least five years of experience teaching agricultural mechanics content in the state of Iowa; (2) having taught agricultural mechanics courses in at least three of the five last years; and (3) having experience with training an FFA Agricultural Mechanics Career Development Event (CDE) team in the last five years.

A snowball sampling technique was used to develop the panel of experts for this Delphi study. Macnee and McCabe (2008) indicated snowball sampling can be used to identify experts in a given field. Using the panel member selection criteria, an initial group of SBAE teachers (n = 6) was identified by the Iowa State FFA Executive Secretary. The nominated panel members were then asked to identify other Iowa SBAE teachers who fit the criteria. At the conclusion of the snowball sampling process, an additional four SBAE teachers were nominated in addition to the original six SBAE teachers.

The panel of experts were comprised of Iowa SBAE teachers (N = 10) who met the aforementioned selection criteria. The teachers had served as SBAE teachers for an average of 27.4 years. Of their teaching tenure, teachers taught for an average of 26.3 years in the state of Iowa. The typical panel member was male (n = 9, 90%), and reported an average age of 56.83. The SBAE teachers indicated they had taught an average of eight stand-alone agricultural mechanics courses in the last five years, with the number of courses ranging from three to 15 per teacher during the five-year period. Teachers specified that their stand-alone agricultural mechanics courses focused on: welding and metal fabrication (SMAW, MIG, oxy-acetylene cutting; n = 3); basic electricity (n = 3); small gas engines (operation, tear-down/assembly, tools, diagnosis; n = 3); agricultural power mechanics (tractor restoration, systems, tools, procedures, finishes; n = 2); agricultural construction (n = 2), advanced welding (computer numerical control [CNC], forge, TIG, position welding; n = 1); agricultural contract (CNC, powder coating; n = 1); basic woods (n = 1); advanced woods (n = 1); concrete (n = 1); and plumbing (n = 1). The qualifications of the 10 teachers who responded to this study well exceeded the minimum selection criteria (i.e., five years of teaching experience and agricultural mechanics teaching experience in three out of the past five years). Our study sought to determine the knowledge and technical skills needed to effectively teach agricultural mechanics in the secondary setting. In a descriptive light, this study served to identify the agricultural mechanics content areas commonly taught in Iowa SBAE programs. Therefore, in the context of this study, experts were operationalized as SBAE teachers who had moderate to high experience with teaching agricultural mechanics in Iowa.

Validity and Reliability

The methodology of this Delphi study provided a foundation to inaugurate content and concurrent validity. Previous research indicated content validity can be established in a Delphi study by carefully selecting participants who have an interest and a depth of knowledge in the topic of focus (Goodman, 1987; Habibi, Sarafrazi, & Izadyar, 2014). Using the specified selection criteria for the panel of experts, the Iowa SBAE teachers who participated in this study had strong interests and backgrounds in agricultural mechanics. Moreover, the three-round Delphi process used in this research study contributed to concurrent validity (Hasson et al., 2000; Sharkey & Sharples, 2001). Hasson and Keeney (2011) indicated the successive rounds of the Delphi process allow the experts to reach a level of agreement on the responses put forth by the group.

The establishment of reliability in Delphi studies is suspect and serves as a limitation for this study. Although certain research studies are constantly cited to account for the reliability (e.g., Dalkey, Rourke, Lewis, & Snyder, 1972) of Delphi studies, an overwhelmingly number of researchers have argued the Delphi method lacks reliability (Hasson et al., 2000; Simoens, 2006; Woudenberg, 1991; Yousuf, 2007). Woudenberg (1991) indicated that the "[e]valuation of the accuracy and reliability of Delphi, being a judgment method, is therefore seriously hampered by the possible influence of person- and situation-specific biases" (p. 134). In essence, each Delphi application represents the development of a new measuring instrument (Woudenberg, 1991).

Along with other debated topics related to Delphi research, there are no hard and fast rules associated with the appropriate number of respondents needed in the expert panel (Thangaratinam & Redman, 2005). Previous research is inconclusive related to the impact of panel size on the reliability of Delphi studies. In one camp, researchers have reported larger sample sizes bolsters the reliability of the composite judgment (Murphy et al., 1998) due to the larger sample size reflecting the opinion of the population, thus resulting in smaller confidence intervals (Hasson & Keeney, 2011). On the other hand, researchers (Woudenberg, 1991; Yousuf, 2007) have questioned this implication because the larger panel size brings about more variation. Loo (2002) indicated the open-first round of the Delphi process makes reliability problematic and Murphy et al. (1998) reported there was "very little actual empirical evidence on the effect of the number of participants on the reliability or validity of consensus processes" (p. 37). The expert panel size in this study aligned with previous recommendations (Hogarth, 1978; Linstone, 1978; Mitchell, 1991; Ziglio, 1996) regarding the appropriate number of participants in a Delphi study. Although, based on the literature review, we will not attempt to claim a linkage between our panel size and level of reliability. Moreover, the inherent person- and situation-specific biases of the SBAE teachers who served as experts in this Delphi study presents the need to exercise caution when attempting to generalize the findings beyond this sample.

Data Collection

Round one: An informational recruitment email was sent to the nominated participants. The email contained a detailed description of the study and the three-round Delphi process, as well as a link to access the first-round instrument. The information about the study, included on the email, sought to provide transparency and reduce the attrition of participants. According to

Hasson et al. (2000), Delphi participants should be "informed of exactly what they will be asked to do, how much time they will be expected to contribute and what use will be made of the information they provide" (p. 1011). Following the initial distribution of instruments in each round, two reminder emails were sent to the participants in five-day increments, based on distribution recommendations from Yun and Trumbo (2000).

Similar to a plethora of previous agricultural education Delphi studies (Breeding, Rayfield, & Smith, 2018; Easterly & Myers, 2017; Lundry, Ramsey, Edwards, & Robinson, 2015; Touchstone, 2015), the three-round Delphi technique was used. A total of three Delphi instruments were used to collect data, one for each round. All survey instruments were developed and distributed using the Qualtrics web-based survey platform. The first round Delphi instrument was comprised of two open-ended questions: *What technical agricultural mechanics knowledge and skills are needed by agricultural education teachers to successfully teach agricultural mechanics courses in Iowa?* and *What laboratory management "teacher skills" (i.e., setting up an oxy-acetylene system for use, changing a table saw blade, etc.) are needed by agricultural education teachers to successfully teach agricultural mechanics courses in Iowa?*. Moreover, the first-round instrument included short-answer and multiple-choice items which inquired about the participants' demographic and background characteristics (e.g., years of teaching experience, years of Iowa-based teaching experience, biological sex, age, and agricultural mechanics teaching experience). The 10 SBAE teachers who participated in the initial round of the Delphi put forth 145 agricultural mechanics topics.

Round two: The second-round instrument was sent via email to the SBAE teachers who participated in the first round of the Delphi. Eight (80%) of the 10 SBAE teachers who participated in the first round participated in the second round of the Delphi. The 145 agricultural mechanics topics gathered in the first round of the Delphi were included on the second-round Delphi instrument. Each topic was paired with a six-point Likert-type scale (1 = *Strongly disagree*; 2 = *Disagree*; 3 = *Slightly disagree*; 4 = *Slightly agree*; 5 = *Agree*; 6 = *Strongly agree*). The items associated with the technical knowledge and skills needed by SBAE teachers were sub-divided into six categories: (1) *Metal Fabrication*; (2) *Structures*; (3) *Soil and Water*; (4) *Machinery*; (5) *Professional Skills*; and (6) *Technology*. The experts were asked to review each topic and indicate their level of agreement on the importance of each agricultural mechanics topic. Aside from the Likert-type items, the second-round instrument included an open-ended question which asked the panel members to include any other items which should be considered. A consensus threshold was developed *a priori*. Items which received a score of five (*Agree*) or six (*Strongly agree*), by at least 75% of the experts were considered to have reached consensus.

Round three: The SBAE teachers who participated in the first two rounds were sent the third-round Delphi instrument, which was comprised of the 16 items that received a score of five or six by 51% to 74% of the experts. Congruent to the second-round instrument, items presented on the third-round Delphi instrument were coupled with a six-point Likert-type scale (1 = *Strongly disagree*; 2 = *Disagree*; 3 = *Slightly disagree*; 4 = *Slightly agree*; 5 = *Agree*; 6 = *Strongly agree*). At the conclusion of the data collection process, items which received a five (*Agree*) or six (*Strongly agree*) by at least 75% of the third-round Delphi experts were considered to have met consensus; items falling below the consensus threshold were excluded from further consideration. Six experts participated in the final round of this study, signifying a response rate of 75%.

Data Analysis

The Statistical Package for Social Sciences (SPSS©) Version 22 software was used to analyze the data collected in this Delphi study. The data gathered from the two open-ended questions on the first-round instrument were analyzed by organizing the SBAE teachers' responses. Duplicate responses were removed and double-barreled responses were segmented into separate items. Additionally, frequencies and percentages were calculated to analyze items related to the SBAE teachers' demographic and background characteristics (e.g., years of teaching experience, Iowa-based teaching experience, biological sex, age, and agricultural mechanics teaching experience).

Descriptive statistics (frequency and percentage) were computed for Likert-type items contained in the two subsequent rounds of the Delphi process. Moreover, the agricultural mechanics items were evaluated to determine if they reached consensus (i.e., ≥ 75% of experts reported agreement or strong agreement), were to be reevaluated in a subsequent round (i.e., received agreement or strong agreement by 51-74% of experts; unique to second round), or were excluded from further consideration (i.e., received agreement or strong agreement from ≤ 50% of experts).

Results

Round One

Collectively, the panel of experts provided a total of 145 topics in the first round of the Delphi study. Of the 145 topics, a total of 84 were associated with technical skills needed by SBAE teachers, and 61 topics related to background "teacher skills"/laboratory management skills needed by Iowa SBAE teachers. Duplicate responses were eliminated from the list, which yielded 127 unique knowledge and skill topics. On the final list of topics, 68 items were technical skills, and 59 items were "teacher skills"/laboratory management skills.

Round Two

A total of 68 items related to the important agricultural mechanics knowledge and skills needed by Iowa SBAE teachers were presented on the second-round instrument of this Delphi study. After completing the second round of the Delphi process, a total of 35 knowledge and skill areas were considered to have met consensus (≥ 75% of experts agreed or strongly agreed with the importance of the item). Nine agricultural mechanics topics received a five (*Agree*) or six (*Strongly agree*) by 51 to 74 percent of the experts. Therefore, the nine topics were presented in the third-round instrument for further consideration. Of the 68 items regarding technical knowledge and skills collected in the first round of the Delphi, 24 items received less than 51% agreement, and were excluded from further consideration (see Table 1).

Table 1

Round Two and Three Findings: Important Agricultural Mechanics Knowledge and Skills Needed by Iowa SBAE Teachers

Agricultural Mechanics Topic	Category	% Agreement
GMAW (MIG welding) process[a]	Metal Fabrication	100
Planning projects[a]	Structures	100
Creating a bill of materials/estimating[a]	Structures	100
Identification and proper use of power tools[a]	Structures	100
Electrical theory[a]	Structures	100
Wiring single-pole circuits[a]	Structures	100
Wiring double-pole circuits[a]	Structures	100
Identification and proper use of surveying equipment[a]	Soil and Water	100
Land measurement[a]	Soil and Water	100
Legal land description[a]	Soil and Water	100
Problem-solving[a]	Professional Skills	100
Patience[a]	Professional Skills	100
Communication[a]	Professional Skills	100
Organization[a]	Professional Skills	100
Teamwork[a]	Professional Skills	100
General safety (electrical, metalworking/welding, woodworking/carpentry, agricultural power)[a]	Professional Skills	100
Metal fabrication safety (welding, metalworking, etc.)[a]	Metal Fabrication	87.5
Oxy-fuel cutting[a]	Metal Fabrication	87.5
Plasma cutting[a]	Metal Fabrication	87.5
Wiring three-way circuits[a]	Structures	87.5
Identification and proper use of hand tools[a]	Structures	87.5
Technical reading[a]	Professional Skills	87.5
Computers[a]	Technology	87.5
Ability to reference parts manuals/schematics electronically[b]	Machinery	85.7
Basic metalworking (shaping, bending, cutting, etc.)[a]	Metal Fabrication	75.0
SMAW (stick welding) process[a]	Metal Fabrication	75.0
GTAW (TIG welding) process[a]	Metal Fabrication	75.0
Introductory carpentry (e.g., structures, rafters, parts of buildings, etc.)[a]	Structures	75.0
Concrete (framing, pouring, etc.)[a]	Structures	75.0
Identification and proper use of measuring/marking tools[a]	Structures	75.0
Using a framing square to determine angles[a]	Structures	75.0
Surveying principles[a]	Soil and Water	75.0
Precision tools (micrometer, caliper, etc.)[a]	Technology	75.0
Alternative energy (biofuels, wind, water, etc.)[a]	Technology	75.0
Gasoline engines (small)[a]	Machinery	75.0
Ability to reference parts manuals/schematics through paper references[a]	Machinery	75.0

Note. [a]Statements that reached consensus in round two. [b]Statements that reached consensus in round three. 1 = *Strongly disagree*; 2 = *Disagree*; 3 = *Slightly disagree*; 4 = *Slightly agree*; 5 = *Agree*; 6 = *Strongly agree*.

The second-round Delphi instrument included 59 items which inquired about the agricultural mechanics "teacher skills"/laboratory management skills needed by Iowa SBAE teachers. Based on the panel of experts' responses in the second round of the Delphi, a total of 49 "teacher skills"/laboratory management skills reached consensus. Seven topics associated with "teacher skills"/laboratory management skills were placed on the third-round Delphi instrument for reconsideration. A total of three topics received 50 percent or less agreement by the experts. These items were excluded from further consideration (see Table 2).

Table 2

Round Two and Three Findings: Important Agricultural Mechanics "Teacher Skills" Needed by Iowa SBAE Teachers

Agricultural Mechanics "Teacher Skill"/Laboratory Management Skill	% Agreement
Providing proper student supervision in an agricultural mechanics laboratory[a]	100
Recognizing unsafe working conditions (i.e., student risk assessment)[a]	100
Having working knowledge of how to properly use fire safety equipment[a]	100
Being able to properly use fire safety equipment[a]	100
Knowing appropriate PPE needed for various agricultural mechanics activities/projects[a]	100
Adhering to OSHA guidelines[a]	100
Recognizing safety concerns regarding damaged tools/equipment[a]	100
Setting up GMAW machines (MIG welders)[a]	100
Maintaining GMAW machines (MIG welders) - changing wire in a GMAW system[a]	100
Maintaining GMAW machines (MIG welders) - checking for shielding gas leaks in a GMAW system[a]	100
Maintaining GMAW machines (MIG welders) - changing contact tips/nozzles in a GMAW welding gun[a]	100
Having working knowledge of ventilation systems[a]	87.5
Understanding of OSHA guidelines[a]	87.5
Recognizing situations which require the use of ventilation systems[a]	87.5
Ensuring proper operation of power tools[a]	87.5
Maintaining/replacing equipment safety devices (e.g., SawStop brake cartridge, etc.)[a]	87.5
Changing attachments on an angle grinder (e.g., wire wheel, cutting disc, or flap disc)[a]	87.5
Setting up SMAW machines (stick welders)[a]	87.5
Maintaining GMAW machines (MIG welders) - applying nozzle gel to parts of a welding gun[a]	87.5
Setting up oxy-fuel equipment[a]	87.5
Maintaining oxy-fuel equipment - securing regulators/leads[a]	87.5
Maintaining oxy-fuel equipment - storage of fuel gas/oxygen tanks[a]	87.5
Maintaining oxy-fuel equipment - cleaning/changing torch heads[a]	87.5
Changing blades on portable power tools (jig, reciprocating, or circular saws, biscuit jointers, etc.) [a]	87.5
Maintaining/repairing/replacing electrical cords[a]	87.5
Ordering parts for tools/equipment[a]	87.5
Completing school paperwork for purchasing purposes[a]	87.5
Ordering consumables[a]	87.5
Organizing tools/equipment[a]	87.5

Determining proper tool/equipment placement in the agricultural mechanics laboratory[a]	87.5
Managing budget of agricultural mechanics laboratory[a]	87.5
Implementing proper laboratory clean-up procedures[a]	87.5
Evaluating students' work using objective evaluation methods[a]	87.5
Evaluating students' work using subjective evaluation methods[a]	87.5
Implementing proper classroom management procedures and enforcement student discipline in the agricultural mechanics laboratory[a]	87.5
Supervising large groups of students who are working on individual or team projects[a]	87.5
Maintaining/adjusting/operating a drill press[a]	75.0
Implementing a lock-out/tag-out system[a]	75.0
Maintaining SMAW machines (stick welders) - maintaining leads[a]	75.0
Maintaining SMAW machines (stick welders) - changing electrode holder[a]	75.0
Maintaining oxy-fuel equipment - checking for leaks[a]	75.0
Adjusting machine blades (e.g., planers, jointers, etc.) [a]	75.0
Changing blades in various stationary power saws (table, chop, radial, miter, or scroll saws, etc.) [a]	75.0
Changing band saw blade/setting blade to correct tension[a]	75.0
Conducting tool / equipment inventory[a]	75.0
Procuring agricultural mechanics tools[a]	75.0
Procuring agricultural mechanics equipment/machinery[a]	75.0
Using effective time management strategies[a]	75.0
Developing a laboratory use rotation schedule (for limited facilities) [a]	75.0

Note. [a]Statements that reached consensus in round two. [b]Statements that reached consensus in round three. 1 = *Strongly disagree*; 2 = *Disagree*; 3 = *Slightly disagree*; 4 = *Slightly agree*; 5 = *Agree*; 6 = *Strongly agree*.

Round Three

The third-round Delphi instrument contained a total of 16 items. Nine of the items were associated with the important agricultural mechanics knowledge and skills (i.e., *Oxy-fuel welding*; *CNC metalworking processes*; *CNC programs use*; *Pole barn construction*; *Wiring four-way circuits*; *Farmstead layout*; *Tractor operation*; *Ability to reference parts manuals/schematics electronically*; *Precision agriculture – GPS technology*), and seven items were related to "teacher skills"/laboratory management skills needed by Iowa SBAE teachers (i.e., *Troubleshooting engine issues*; *Performing engine tune-ups*; *Demonstrating proper operation of engines*; *CNC equipment set-up/use/maintenance (torch set-up*, *linking computers to plasma tables*, *CNC set-ups, etc.)*; *Maintaining CNC equipment - replacing consumables*; *Making adjustments to CNC equipment - adjusting torch location to initiate cut*; and *Maintaining CNC equipment - lubrication of CNC equipment*). Of the 16 items presented to the experts in the third round, only one topic, *Ability to reference parts manuals/schematics electronically* (85.7% agreement), reached consensus. At the conclusion of the third round of the Delphi process, all items that failed to meet the consensus threshold were excluded from any further consideration. A total of 85 items reached consensus in this Delphi study; 36 items pertained to the important agricultural mechanics knowledge and skills needed by Iowa SBAE teachers and 49 topics related to the agricultural mechanics "teacher skills"/laboratory management skills needed by Iowa SBAE teachers.

Conclusions, Discussion, & Recommendations

The present study yielded a foundational list of 85 agricultural mechanics instruction-related knowledge and technical skill competencies that Iowa SBAE teachers should have. Thirty-six of these items were technical skill competencies while 49 "teacher skills"/laboratory management skills competencies were identified. We emphasize that the sequencing of the items in both the technical skills and "teacher skills"/laboratory management skills lists is not indicative of the level of importance (e.g., an item with 100% agreement is no more important in comparison to another item with 100% agreement). As also noted by Pate et al. (2012) and based on the extensiveness of the list that emerged in the present study, there was much emphasis on laboratory management (i.e., "teacher skills"/laboratory management skills), indicating that the teachers who participated in the present study placed an emphasis on ensuring that SBAE teachers who provide instruction in agricultural mechanics content should be competent in a myriad of knowledge and skill areas beyond solely technical skills. As indicated by prior research (Johnson & Schumacher, 1989; Johnson et al., 1990; McKim & Saucier, 2011a, 2011b, 2012, 2013; Saucier & McKim, 2011; Saucier et al., 2012; Saucier et al., 2014; Schumacher & Johnson, 1990), competence in agricultural mechanics laboratory management-related knowledge and skills (i.e., "teacher skills"/laboratory management skills) are of the utmost importance for both pre-service and in-service teachers' professional growth and development as SBAE teachers.

This list could potentially be of great use by the agricultural teacher preparation programs in Iowa and the Iowa Department of Education (DOE) as well as teacher preparation programs outside of the state. Iowa agricultural teacher preparation institutions could use this list to frame and revise pre-service teacher education coursework while the Iowa DOE, in conjunction with the teacher preparation programs, could use these data to provide professional development (PD) opportunities for in-service teachers. Teacher preparation programs outside of Iowa, particularly in neighboring states where Iowa teachers may be more likely to relocate to in the future versus states that are further away, could use this list as a method to determine the agricultural mechanics knowledge and skills that may be needed for teachers in those respective states. However, we caution that the items listed in the present study may not necessarily apply to all states' curricula, teachers' needs, industry needs, or students' interests. We recommend that agricultural education researchers conduct additional studies in other states to develop a greater understanding of the agricultural mechanics technical content and "teacher skills"/laboratory management skills knowledge and skills pertinent to those other states.

In considering the results of the present study, we noted that the "teacher skills"/laboratory management skills' list was very safety- and laboratory management-oriented, as could be expected. As Saucier et al. (2014) indicated, teachers should be well-prepared to effectively manage the learning environment, particularly on matters related to safety. Drawing upon our results, we wonder which of the items that emerged in the present study are the most important to learn, and which of these should be learned through pre-service teacher coursework? Burris et al. (2005) and Whittington (2005) noted that teacher preparation programs have a responsibility to help prepare new teachers to engage their own students in various agricultural content; however, Burris et al. (2010) acknowledged that practical experience in a classroom setting helps to significantly improve self-efficacy, as well as associated knowledge and skills, in a technical agriculture content area (e.g., agricultural mechanics). As teacher preparation faculty, we should recognize that pre-service and in-service teachers may often have to gain experience outside of a university classroom (i.e., teaching in an actual SBAE program) to more fully facilitate the development of professional growth, knowledge, and skills related to technical skills and "teacher skills"/laboratory management skills.

Regarding welding knowledge and skills, which have been documented as a focus area for SBAE teacher development (Blackburn et al., 2015; Leiby et al., 2013; Pate et al., 2012), an interesting point to note was that the gas metal arc welding (GMAW) process seems to be held in higher regard in terms of importance versus other areas of welding (e.g., the shielded metal arc welding [SMAW] and gas tungsten arc welding [GTAW] processes). Several questions emerged from this observation. Do teachers perceive that industry stakeholders are more likely to employ students who are competent in the GMAW process? Do teachers perceive that industry stakeholders are putting greater emphasis on using the GMAW process in their businesses? This is a possible explanation, as the GMAW process is widely used in many industrial settings, such as repair facilities, agricultural equipment manufacturers, and so forth. Moreover, could these teachers' greater emphasis on teaching the GMAW process signify that many of their students are pursuing career opportunities that would use the GMAW process more (i.e., manufacturing, indoor equipment repair services, etc.)? Perhaps this discrepancy may relate to the ease of teaching different welding processes. Rose, Pate, Lawver, Warnick, and Dai (2015) indicated that perhaps secondary students can grasp GMAW process concepts more easily than SMAW process concepts and should thus initially learn how to weld via the GMAW process. Could these combined factors have an impact on welding instruction in SBAE programs in Iowa? Follow-up studies that address these questions would be beneficial to the profession.

The results of the present study indicated that many advanced technologies and practices, such as *Precision agriculture – GPS technology*, *CNC programs use*, and so forth, were as important for teachers to have technical expertise in as compared to the final compiled list of agricultural mechanics knowledge and skills. Considering that the agricultural industry is in a state of rapid change technologically-speaking (Doerfert, 2011; Stripling & Ricketts, 2016), we considered several possibilities that may provide suitable explanations for this. Per McCubbins et al. (2016), SBAE teachers are often poorly-equipped to teach many topics in agricultural mechanics, particularly those that are more technologically-advanced or require a more specialized skill set (e.g., computer-aided drafting [CAD], etc.). Shultz et al. (2014) found SBAE teachers frequently reported that they believe a topic is important to teach; yet, they often lack the competency to teach the topic.

Perhaps a lack of equipment could influence teachers' perceptions about the important, or even relevance, of a topic. McCubbins et al. (2017) described that a relationship exists between perceived tool and equipment adequacy to teach a selected topic and the perceived competence to teach said topic. Is the same true with the teachers who provided data for the present study? Moreover, does the possibility exist that these SBAE teachers may be out-of-touch with modern practices used by industry? Considering that many of these teachers are approaching retirement age in the coming years, the likelihood may exist that their engagement with industry stakeholders may have declined in recent years as these teachers near the end of their careers. Sorensen, Lambert, and McKim (2014) noted that later-career teachers often see limited need for engaging in agricultural mechanics-oriented PD themselves; thus, the possibility exists that these teachers may have in turn sacrificed opportunities to engage with industry stakeholders and learn about new and emerging agricultural technologies. Further work should examine this phenomenon more deeply with Iowa SBAE teachers, as they may be forgoing important learning experiences and connections with industry that could benefit their programs and their students.

Considering that many of the agricultural mechanics knowledge and skill areas that were deemed important by the teachers included in the present study, we noted that many of these items have historically been included in traditional agricultural mechanics coursework, such as woodworking, electrical wiring, and more (Burris et al., 2005). As agricultural education researchers, we postulate the possibility that some of these topics may in fact now be outdated in their utility for many secondary students and may instead be more reflective of the era of vocational agriculture described by the National Research Council ([NRC] 1988). As the typical teacher in the present study was male and had taught for 27.4 years, it is reasonable to speculate that these teachers were secondary students during the 1970s and 1980s and had been exposed to the vocational agriculture model that emphasized production agriculture-oriented knowledge and skills (NRC, 1988), thus potentially influencing their beliefs about what agricultural mechanics instruction should resemble at a young age. These early experiences with the vocational agriculture model could have created long-lasting impacts about these teachers' personal philosophies of SBAE and its content. Rasty, Anderson, and Paulsen (2017) noted that there are often correlations between SBAE teachers' perceived importance about content areas and their educational experiences as secondary students. Perhaps that is the case with the teachers in the present study. We believe that as these teachers retire and younger teachers fill their former positions, the evolution of agricultural mechanics instruction, as well as laboratory use, will be an interesting phenomenon to observe. Agricultural education researchers should consider documenting the lived experiences of late-career teachers to address the points raised in the present study as well as to study the future changes coming to agricultural mechanics instruction.

In the light of increased emphasis on programs of study and college and career readiness in the context of CTE (Stone, 2017), we noted that none of the *Professional Skills* (i.e., soft skills) were rejected between the rounds. As such, we were left with some questions. Do teachers see these items as very relevant given greater pushes toward soft skills integration in SBAE? Moreover, do teachers perceive that the inclusion of basic technical skills education along with basic soft skills (e.g., showing up for work on time, filling out a job application, etc.) is adequate for preparing students? Per Free (2017), soft skill development is a timely topic that SBAE teachers as well as students should be prepared to address and implement, and it is important that such skills (e.g., *Teamwork*, *Problem-solving*, etc.) be well-developed in both pre-service and in-service teachers who can facilitate such learning for their current and future students. Further, Stone (2017) prescribed that all CTE teachers, including SBAE teachers, should be prepared to build relevant, robust, and sustainable programs that align with societal and industry needs, and prepare the future workforce (i.e., secondary students) to address those needs. We speculate that further research would be useful in helping to better understand these issues.

In the context of SBAE, teacher competence in agricultural mechanics is anticipated to be an issue in the coming years (Blackburn et al., 2015; Burris et al., 2005). However, based upon the results of the present study, we wonder how agricultural mechanics will continue to evolve as a content area. Rasty and Anderson (2017) found that Iowa SBAE teachers perceive that many agricultural mechanics skills will continue to increase in importance in the future, particularly skill and content areas that are more technologically advanced (e.g., robotics, etc.). As was the case with the present study, Rasty and Anderson (2017) did not gather data from industry stakeholders, indicating that a gap in the literature exists. Our question is: do the results of prior work (Rasty & Anderson, 2017) and the present study align with what industry perceives as the important agricultural mechanics knowledge and skills for teachers as well as students? Further, how should agricultural mechanics look and what content should be taught within this area as teacher preparation and SBAE programs progress deeper into the 21st century?

Considering that SBAE programs are continuing to advance towards specialized, focused courses and programs of study (e.g., agricultural biotechnology, agricultural engineering, natural resource systems, etc.) and away from broad, general agriculture-oriented coursework (i.e., multiple short-term, low depth topics under the umbrella of one particular course or throughout a handful of courses) that has often focused on skills and job preparation (Phipps et al., 2008), it is important to consider what impacts this may hold on agricultural teacher preparation programs and processes. For example, is it imperative that teachers enrolled in traditional teacher preparation programs continue to be exposed to coursework in a wide range of agricultural topics (e.g., one course in animal science, another in agricultural mechanics, etc.)? This preparation process orientation could, over time, reinforce the notion that agricultural education should be composed of extremely broad, numerous learning experiences that may limit the development of specialized knowledge and skills (such as those associated with agricultural mechanics) that would otherwise allow SBAE teachers to become more technically-prepared in a select area related to SBAE. Whittington (2005) described the need for SBAE teachers to be technically competent. Perhaps a more concerted effort to allow for specialized programs tracks during teacher preparation and technical agriculture coursework would be beneficial to ensuring that new teachers' knowledge and skill development in their chosen content areas of focus are more thoroughly defined. As a result, teachers may be more comfortable in addressing the need to advance their own local programs toward specialized coursework that may, over time, better prepare secondary students for opportunities in the agricultural industry and beyond. Research that brings together additional stakeholders of SBAE (e.g., teacher educators, SBAE teachers, industry representatives, school administrators, etc.) would be useful to help address these items.

The agricultural industry depends upon well-trained and capable SBAE teachers to help provide the future workforce for the industry (Roberts & Ball, 2009). Thus, teachers should be prepared to provide quality instruction in numerous areas (Roberts & Ball, 2009), including agricultural mechanics (Burris et al., 2005; Rasty et al., 2017). Alignment with industry is a must if programs are to remain relevant and established in providing real-world learning opportunities (Rasty & Anderson, 2017). Whittington (2005) noted that technical competence is a fundamental development tenet for an SBAE teacher. However, how can teachers be well-prepared to deliver quality agricultural mechanics instruction? In light of further advances to reduce the mandatory credit hours of preservice teachers, prescribing additional coursework may not be a suitable, nor sufficient, answer (Hubert & Leising, 2000). Rather, aligning existing preservice teacher preparation curricula to accurate, timely research data may be a start. Further, additional PD throughout the early career stages may be useful. Sorensen et al. (2014) noted that agricultural mechanics-related PD was a great interest area for early-career teachers. PD should be engaging enough to attract veteran teachers as well, though, to help ensure that SBAE teachers are growing and adapting to changes in industry. Preparing the workforce of the future is and should be a significant priority for SBAE programs (Stripling & Ricketts, 2016).

As the workforce development process continues to change based on industry and societal needs (Stone, 2017), we recommend that, per Blackburn et al. (2015), Leiby et al. (2013), and Pate et al. (2012), additional research should concentrate on identifying specific knowledge and skill competencies in agricultural mechanics content areas beyond welding to determine other important topics that teachers should be knowledgeable and skilled in (e.g., electricity, emerging technologies, biofuels, etc.). This work should be inclusive of industry stakeholders to maximize alignment between SBAE programs and industry (Rasty & Anderson, 2017). Such data could be instrumental in helping to define the evolution of agricultural mechanics as a content area. As teacher preparation stakeholders in Iowa, we believe that an agricultural mechanics needs assessment conducted with Iowa SBAE teachers would be useful as well. This needs assessment should be conducted after the completion of a forthcoming study focused on industry experts' perspectives, however, to more fully maximize the congruence of needs expressed by SBAE stakeholders.

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