Technical Agriculture Skills Teachers Need to Teach Courses in the Animal Systems Pathway

Abstract

Fundamentally, agricultural teacher education programs and their faculty are tasked with preparing competent teachers capable of teaching students enrolled in public schools. As part of their design, an important facet of these programs is ensuring pre-service teachers are ready to provide educational opportunities in aspects of school-based agricultural education (SBAE), including teaching technical agriculture skills to students. We used a three-round Delphi technique to identify the technical agriculture skills SBAE teachers in Illinois and Iowa need to effectively teach courses in the Animal Systems pathway within the broader Agriculture, Food, and Natural Resources (AFNR) Career Cluster. Thirty-four SBAE teachers who were nominated by state-level SBAE leaders and other SBAE teachers in their states contributed data for our study. Twenty-two teachers participated in all three rounds. In total, we identified 35 technical agriculture skill items. To help ensure teachers are competent and prepared to teach courses in the Animal Systems pathway, we outline several approaches agricultural teacher educators should contemplate: (1) facilitating opportunities to foster technical agriculture skill development within agricultural teacher education programs, (2) collaborating with agricultural faculty who teach technical agriculture courses to pre-service teachers, and (3) using our list of 35 skills to facilitate future scholarly investigation on the topic. While not generalizable beyond the SBAE teachers in these two states, we do believe our findings have value for SBAE stakeholders. To overcome the limitation of generalizability and to delve deeper into teachers' technical agriculture skill needs, we suggest that our study be replicated in other states.

Keywords: technical agriculture; skills; animal

Introduction

School-based agricultural education (SBAE) programs are located in public schools across the United States. These programs are designed to serve students of various backgrounds and are traditionally intended to reflect the needs of the surrounding community. As program leaders, SBAE teachers wear many hats and serve various differing yet often overlapping roles, including preparing students to engage in leadership skill development activities (Phipps et al., 2008), addressing local and regional needs related to workforce development (Wells & Hainline, 2021; Wells et al., 2021), and providing the agricultural industry with a capable, well-trained workforce (Stripling & Ricketts, 2016). Because of these important and consequential roles, it is imperative that well-prepared, effective SBAE teachers lead SBAE programs. Among other traits, effective SBAE teachers are knowledgeable about agricultural subject matter (Eck et al., 2019). Agricultural subject matter knowledge encompasses a broad range of categories, including agricultural mechanics, agribusiness, and animal science (Phipps et al., 2008), and has long been deemed as a trait of effective SBAE teachers (Eck et al., 2019; Roberts & Dyer, 2004).

Within the context of agricultural teacher education programs, technical agriculture courses such as Introduction to Animal Science and Introduction to Plant Science are used to provide pre-service teachers with the technical agriculture background relevant to their forthcoming professional responsibilities (Whittington, 2005). Subsequently, just as the agricultural industry is in a constant state of fluctuation to better serve the needs and desires of the modern world (Doerfert, 2011), SBAE teachers' agricultural subject matter knowledge needs

change as well. Thus, a challenge remains: establishing that the agricultural subject matter knowledge of SBAE teachers is up-to-date and reflective of the expertise needed to successfully lead SBAE programs.

In recent years, SBAE stakeholders have undertaken efforts nationally to help ensure SBAE coursework is flexible and remains congruent with the needs of the agricultural industry. In 2015, The National Council for Agricultural Education issued a revised list of Agriculture, Food, and Natural Resources (AFNR) Career Cluster Content Standards across eight career pathways: (1) Agribusiness Systems, (2) Animal Systems, (3) Biotechnology Systems, (4) Environmental Service Systems, (5) Food Products and Processing, (6) Natural Resource Systems, (7) Plant Systems, and (8) Power, Structural, and Technical Systems. The content standards were designed to both align with the needs of the agricultural industry and to promote the college and career success of students (The Council, 2015). Moreover, The Council's (2015) broader mission was to facilitate the informed progression of SBAE programs via these revised standards. In effect, these changes and their underlying motivations have implications for SBAE stakeholders, such as agricultural teacher education programs, especially when considering the preparation of effective teachers.

Considering SBAE teachers directly impact students and their respective programs, schools, and communities at-large through the workforce development training they provide, it is imperative that teachers are prepared to competently lead instruction in technical agriculture skills (Wells & Hainline, 2021; Wells et al., 2021). Regarding workforce development needs, Slusher et al. (2011) worked with industry representatives to identify the technical skills SBAE program graduates need for entry-level employment in the animal agriculture industry and found that graduates need a wide range of technical skills, such as transporting livestock and operating equipment safely, to successfully procure entry-level employment.

Similar to Slusher et al. (2011), Ramsey and Edwards (2011) explored agricultural industry stakeholders' expectations for students' technical skill acquisition through their Supervised Agricultural Experiences (SAEs), finding that the stakeholders in their study expected students to learn a wide range of technical skills, particularly those related to animal agriculture (e.g., animal nutrition, animal handling). In addition to industry stakeholders' expectations, Ramsey and Edwards (2012) noted that SBAE teachers expect students to acquire numerous entry-level technical skills through their SAEs. Considering these findings, it is logical to suggest teachers should be able to competently provide students with instruction in technical agriculture skills to help better-prepare them for career opportunities in the agricultural industry.

In addition to workforce development needs, the lack of teacher competence can negatively impact student learning, particularly when working with students in SBAE laboratories (Hainline et al., 2019; Wells & Hainline, 2021). A great deal of instruction in SBAE programs is laboratory-based (Phipps et al., 2008; Shoulders & Myers, 2012; Twenter & Edwards, 2017), thus creating the need for teachers to be prepared to safely manage their learning spaces (Saucier et al., 2014). To adequately manage the laboratories they use (e.g., school farms, livestock management facilities) and support the intended learning outcomes associated with using such environments, SBAE teachers must be knowledgeable about the agricultural subject matter they teach (Wells & Hainline, 2021).

As part of their professional responsibilities, teachers must make sound judgments and actively work to protect and safeguard their students (McDaniel, 2020). Teacher competence is a must-have (Zirkle, 2017). Zirkle (2017) also indicated that teachers must ensure their learning environments are safe and ready for students. Love (2013) further specified teachers are more

likely to encounter undesirable issues if teachers are not prepared for their professional responsibilities, including being knowledgeable in their subject matter. Proactively approaching possible professional concerns can be successfully accomplished through various means, such as by ensuring teachers are well-prepared for their work before they enter into the profession (Love, 2013).

In conjunction with teacher competence concerns resulting from inadequate teacher training (Love, 2013), teacher retention is also of concern to SBAE stakeholders. Within their review of literature, Solomonson et al. (2018) noted that teacher retention can be increased through four approaches: (1) sufficient teacher preparation and training, (2) purposeful professional development, (3) possessing adequate self-efficacy, and (4) increased experiences in the classroom. Solomonson et al. (2018) further indicated that a teacher's *Lack of Confidence to Teach the Curriculum* as the top affective factor impacting a SBAE teacher's decision to leave the classroom. Other scholars' (Darling-Hammond, 2003; Darling-Hammond et al., 2002) findings suggest teachers are less likely to leave the profession when they are adequately prepared for their professional responsibilities.

Haynes (2014) and Ingersoll and Smith (2003) noted that appropriate teacher training and professional development opportunities can positively impact teacher retention. It is conceivable that if pre-service and in-service SBAE teachers perceived that they were well-trained to teach their subject matter, they may be more likely to remain in the classroom longer. As teacher retention is of the utmost priority to the agricultural teacher education profession (Foster et al., 2020), the role that agricultural teacher education programs have in preparing teachers to be competent in their agricultural subject matter knowledge should not go unnoticed.

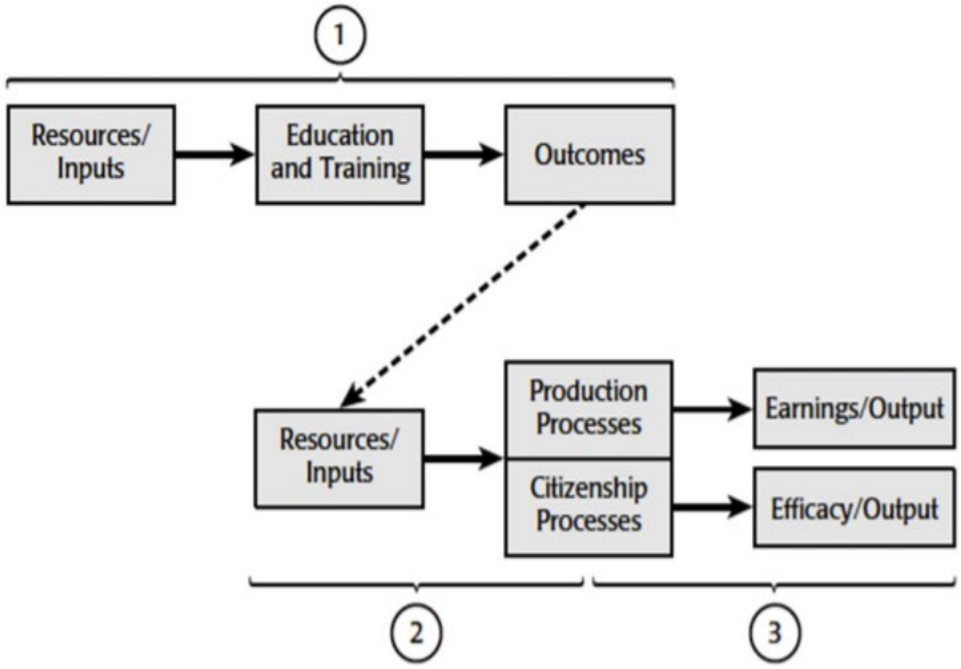
Recent literature (i.e., Hainline & Wells, 2019; Swafford & Hagler, 2018; Wells et al., 2021) has focused much attention on identifying the knowledge and skills SBAE teachers need to successfully teach agricultural mechanics. Meanwhile, there has been little recent literature on other areas of technical agriculture, such as plant science, soil science, and animal science. To help fill this gap, Albritton and Roberts (2020) recently explored the technical agriculture skill needs of beginning teachers. While their study addressed numerous agricultural subject matter areas, a primary limitation of their study arose simply due to its scope. What about the technical agriculture skills needed by teachers regardless of experience level? We sought to address this question specifically. Simultaneously, we also sought to build upon existing literature related to this topic (i.e., studies focused on agricultural mechanics knowledge and skills needed by teachers) and expand the literature related to the technical agriculture skill needs of SBAE teachers. Our study, which focused specifically on the Animal Systems pathway, was part of a larger effort to address such needs. Our overarching goal was to develop and provide a list of specific technical agriculture skills to better inform stakeholders involved in agricultural teacher education programs (e.g., agricultural teacher educators, agricultural faculty at-large).

Theoretical Framework

We used Swanson and Holton's (2001) model of human capital theory (HCT) to underpin our study (see Figure 1).

Figure 1

A Model of Human Capital Theory



From *Foundations of Human Resource Development* (p. 110), by R. A. Swanson and E. F. Holton, III, 2001, Berrett-Koehler Publishers, Inc. Copyright 2001 by Berrett-Koehler Publishers, Inc. Reprinted with permission.

Human capital includes both the health and education of people and the stock of educated people. Human capital is measured through an assessment of the quality and quantity of formal education received by individuals (Lutz & KC, 2011). Sweetland (1996) noted that education is consistently identified as the principal human capital investment for empirical analysis. Further, education has served as the foundational human capital component of several prior studies in agricultural education (i.e., Easterly & Myers, 2017; Hendrix & Morrison, 2018; Robinson & Baker, 2013; Robinson & Garton, 2008; Wells & Hainline, 2021) that evaluated the skills, needs, and education required of individuals in the context of workforce development. In their model of HCT, Swanson and Holton (2001) describe three key relationships that transpire throughout the human capital development process. Our study used the first two relationships of the model. The first relationship relates to the outcomes of resources, inputs, and education and training of individuals. These outcomes are subsequently applied as inputs as the individual proceeds to earn employment within an organization and applies the education and training to the work they perform. In turn, the productivity for the workplaces that individuals occupy is increased as they apply their educational outcomes as inputs to their employer (Swanson & Holton, 2001).

Baye and Prince (2014) further expressed the application of an individual's education outputs transitioning to become inputs to their employer by describing human capital as a specialized investment that firms are required to make in order to yield returns. Their definition indicates that employers are willing to invest in their employees by helping them acquire a set of specific knowledge or skills related to their role in the organization, which improves human capital as a resource. When examining the connection between relationships one and two in

Swanson and Holton's (2001) model, knowledge and skills acquired as a result of an employee's education should directly articulate as inputs for an employer (production process), thus serving as a benefit. When employees are able to contribute relevant knowledge, education, and skills that can be used by their employers, employers may in turn be inclined to reduce their direct financial investment into human capital. This creates an economic benefit for both employees and employers.

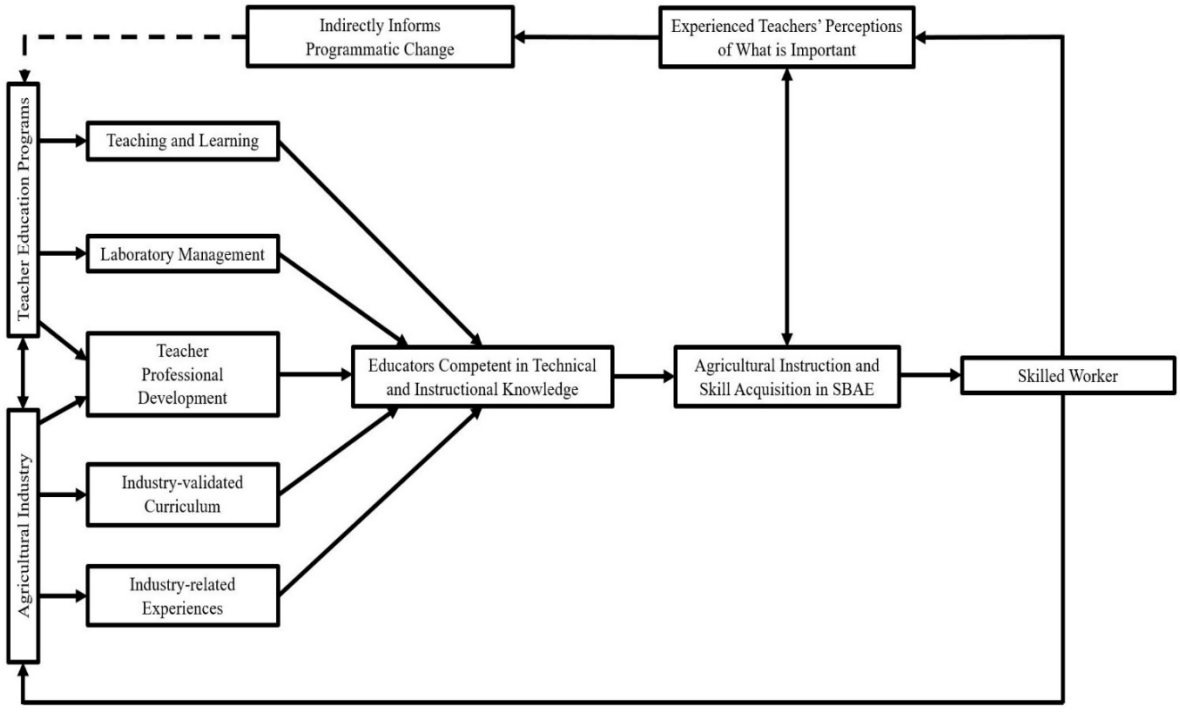
An employee's ability to provide knowledge, skills, and education to their employer stems directly from the education they received in relationship one of the HCT model. In the context of agricultural teacher education, SBAE teachers who are competent in their agricultural subject matter knowledge will both: (1) have a positive impact on increasing the knowledge and skillsets of their students and (2) will contribute to creating a connection between relationships one and two as their employers (i.e., local school districts) invest in them as employees via further professional training and development throughout their careers.

Conceptual Framework

We used Wells et al.'s (2021) Agricultural Teacher Education and Agricultural Industry Partnership Model (see Figure 2) to conceptually frame our study.

Figure 2

The Agricultural Teacher Education and Agricultural Industry Partnership Model



From "A Regional Study of the Agricultural Mechanics Knowledge and Skills Needed by School-based Agricultural Education Teachers," by T. Wells, M. S. Hainline, B. D. Rank, K. W. Sanders, and S. B. Chumbley, 2021, *Journal of Agricultural Education, 62*(2), p. 162 (https://doi.org/10.5032/jae.2021.02148). Copyright 2021 by the *Journal of Agricultural Education*. Reprinted with permission.

Our particular interest was on the *Experienced Teachers' Perceptions of What is Important* aspect of their model. Wells et al.'s (2021) model built upon Roberts and Ball's (2009) Content-based Model for Teaching Agriculture through accounting for other factors (e.g., *Teacher Professional Development*, *Teacher Education Programs*) that inform the development of teachers' technical agriculture knowledge and skills and the teachers' instructional practices that foster skill learning opportunities within SBAE programs. Wells et al. (2021) noted that experienced teachers can provide insight into the development of competent, prepared SBAE teachers, as they are often well-informed regarding the realities of their professional responsibilities. As such, the solicitation of experienced teachers' perceptions should not be overlooked as an important component for helping to move SBAE forward.

Purpose

The purpose of our study was to describe the technical agriculture skills teachers in Illinois and Iowa need to effectively teach courses in the Animal Systems pathway within the broader AFNR Career Cluster. We used the perceptions of knowledgeable, experienced SBAE teachers to accomplish our purpose. Our study was part of a larger study focused on identifying the technical agriculture skills SBAE teachers in these states need. Our study specifically addressed the American Association for Agricultural Education (AAAE) National Research Agenda (NRA) Research Priority 3: Sufficient Scientific and Professional Workforce That Addresses the Challenges of the 21st Century (Stripling & Ricketts, 2016).

Methods

We conducted a three-round Delphi study to obtain a consensus among SBAE teachers in Illinois and Iowa regarding their perceptions of the most important technical agricultural skills teachers should have to effectively teach courses in the Animal Systems pathway. Delphi methods have been used in several recent Agricultural Education studies (i.e., Hainline et al., 2019; Rinker et al., 2021; Wells et al., 2021). Further, Delphi methods are effective for building consensus among a panel by using a series of questionnaires (Linstone & Turoff, 1975).

Nomination Process

The purposeful, careful selection of qualified panelists has been described as the "keystone to a successful Delphi study" (Stitt-Gohdes & Crews, 2004, p. 60). Our study included Illinois and Iowa SBAE teachers nominated by state-level SBAE leaders (e.g., agricultural teacher educators, state staff) to provide input regarding the technical skills needed to teach courses in the Animal Systems pathway. We requested that these leaders identify individual SBAE teachers in their respective states who they believed to be effective teachers of courses in the Animal Systems pathway. When this initial nomination process concluded, 57 SBAE teachers were nominated for participation in our study. Using a snowball sampling technique, we asked these 57 initially-nominated teachers to in turn nominate other teachers who they believed were effective teachers of courses in the Animal Systems pathway. When the nomination process concluded, 111 SBAE teachers were nominated to serve as panelists in our study.

Instrumentation / Data Collection

We used three separate Qualtrics-based survey instrument to collect data during each round of our three-round Delphi study (i.e., a different instrument for each round of our study). For each round, we sent a survey instrument to the panelists via e-mail. To increase our response rate, we subsequently sent two reminder e-mails to non-respondents in seven-day increments. To

reward for their participation in our study, we sent a small refrigerator magnet with the *Teach Ag* logo printed on it to each panelist who responded to our first-round instrument. We sought to follow the recommendations of Dillman et al. (2014) to motivate panelists to respond to our second- and third-round instruments by providing them with a small token of appreciation for their assistance with our efforts.

Our first-round recruitment e-mail included a brief description of our study, information regarding the scope of the Delphi process, an Institutional Review Board (IRB) -approved informed consent form, and a link to access our first-round instrument. Our first-round instrument included four items. The first item was an open-response item that asked the panelists to detail the most important technical agriculture skills teachers need to teach concepts in the Animal Systems pathway. The second item was multiple-answer and asked the panelists to specify the previous experiences that served to influence their perceptions regarding the technical skills they deemed to be important. The multiple-answer item included 19 experiences (e.g., "Experiences teaching agricultural education coursework," "Experiences working in the agricultural industry," and "My experiences with FFA activities [e.g., CDE teams, etc.]") for the panelists to select from along with an item that allowed teachers to specify other experiences we did not list. The third question asked about the panelists' number of years of teaching experience. The final item prompted the panelists to nominate other knowledgeable teachers who teach courses in the Animal Systems pathway.

We originally sent our first-round instrument to 57 SBAE teachers. The snowball sampling technique incorporated in the instrument generated the nomination of 54 additional SBAE teachers to serve as panelists. Of the 111 teachers nominated to participate in the first round, 34 SBAE teachers responded in the first round, yielding a response rate of 30.6%.

After round one concluded, we reviewed the open-ended responses provided by the panelists. We aggregated duplicate responses, which resulted in the identification of 99 unique skill items. We included these 99 skills on our second-round instrument, which we sent to the 34 panelists who participated in round one. We asked the panelists to review the 99 skill items and use a six-point rating scale (1 = *Strongly disagree*; 2 = *Disagree*; 3 = *Slightly disagree*; 4 = *Slightly agree*; 5 = *Agree*; 6 = *Strongly agree*) to indicate their level of agreement regarding the importance for SBAE teachers to have competency with each skill item. Based on recommendations set forth by Dillman et al. (2014), we grouped similar skill items together on our second-round instrument to enhance the readability and improve response efficiency. Specifically, we presented the skill items on our second-round instrument in the following nine categories: (1) General Animal Systems skills; (2) Business and Communications skills; (3) Animal Handling and Restraint skills; (4) Animal Anatomy, Physiology, and Biology skills; (5) Animal Reproduction and Breeding skills; (6) Animal Nutrition skills; (7) Animal Management skills; (8) Animal Health and Care skills; and (9) Animal Products, Processing, and Marketing skills.

We sent our second-round instrument to the 34 panelists who participated in the first round of our study. Twenty-three out of 34 panelists (response rate = 67.6%) participated in the second round of our study. We set the consensus criteria outlined in Table 1 *a priori*. We used these criteria as a metric to determine if each skill item had met consensus amongst the panel.

Table 1

Consensus Criteria Based on Percentage of Panelists who Indicated a 5 (Agree) or 6 (Strongly agree) on a Given Item

Criteria Decision	%
Met consensus	≥ 75
Included on the third-round instrument for reevaluation	51 to 74
Omitted from further consideration	< 51

Twenty-four of the 99 skill items met consensus in the second round. Fifty-one to 74% of the panelists rated 55 skill items as a 5 (*Agree*) or 6 (*Strongly agree*). These 55 skill items were subsequently included on our third-round instrument. Twenty items fell below the bottom threshold of our consensus criteria. These 20 items were thus excluded from further consideration.

Our third-round instrument included 55 skill items. We sent our third-round instrument to the 23 panelists who had previously responded to both our first- and second-round instruments. Twenty-two panelists (response rate = 95.7%) responded to our third-round instrument. Congruent with the procedures we employed with our second-round instrument, we asked the panelists to designate their level of agreement with the importance of each skill item using the same six-point scale (1 = *Strongly disagree* to 6 = *Strongly agree*). As with the second round of our study, we used the same consensus criteria to evaluate the skill items (see Table 2). Of the 55 items presented on our third-round instrument, 11 items met consensus and we eliminated the remaining 44 skill items from further consideration. At the conclusion of our three-round Delphi study, 35 skill items met consensus among the panelists.

Validity and Reliability

Our implementation of a three-round Delphi process in which respondents identified and met consensus of agreement on the items over several rounds bolstered the concurrent validity of this research (Hasson & Keeney, 2011; Sharkey & Sharples, 2001). To assess content validity, we asked a panel of experts to review each of our three instruments. Our panel consisted of three agricultural teacher educators who were on the faculty at three different land-grant universities. We asked these three panel members to review our instruments and provide suggestions for improvement. Based on the feedback we received from the panel, we adjusted the wording of some items and reformatted the directions for enhanced readability.

Concerning reliability, Dalkey et al. (1972) indicated the number of panelists in a Delphi study serves as a metric to determine the reliability of the instrument. Specifically, Dalkey et al. (1972) noted a panel of 11 members would yield a reliability coefficient of 0.70 and a panel of 13 or more members would garner a reliability coefficient of 0.90. Based on Dalkey et al.'s (1972) recommendations for reliability, the number of panelists in all three rounds of our study (Round One, n = 34; Round Two, n = 23; Round Three, n = 22) exceed the posited threshold and we would thus expect to yield reliable findings. While we recognize that our study meets the reliability threshold posited by Dalkey et al. (1972), the reliability of Delphi studies has been disputed by many scholars (Hasson & Keeney, 2011; Williams & Webb, 1994; Woudenberg, 1991; Yousuf, 2007). Woudenberg (1991) pointed out the Delphi process yields judgments and not measurements—which have the propensity to be influenced by situation- and person-specific biases. In an attempt to mitigate situation-specific biases (i.e., factors), we standardized the recruitment procedures, instrument dissemination procedures, instrument designs, and the number

of Delphi rounds. The inherent presence of person-specific biases associated with this study served as a key limitation related to the establishment of reliability.

Data Analysis

We used IBM® SPSS® Statistics Version 26 software to analyze the data we collected throughout our study. We analyzed the open-ended items on the first-round instrument by organizing the responses into categories and removing duplicate responses. We calculated measures of central tendency and dispersion along with frequencies and percentages for the multiple answer and short-answer items in our first-round instrument. We calculated frequencies and percentages to determine if the scale items in the second and third rounds of our Delphi study had met our consensus criteria.

Results

Participants

One-hundred and eleven SBAE teachers were nominated to participate in our study; 34 agreed to do so as panelists. These 34 panelists had taught an average of 13.47 (*SD* = 8.20) years. We asked each panelist to identify any source of experience that they believed influenced their perceptions of the technical agriculture skills teachers need to teach courses in the Animal Systems pathway. The three experiences panelists most frequently indicated as an influence were: "Experiences teaching agricultural education coursework" (*f* = 27; 79.4%), "Experiences working in the agricultural industry" (*f* = 26; 76.5%), and "My experiences with FFA activities (e.g., CDE teams, etc.)" (*f* = 17; 50.0%; see Table 2).

Table 2

Experiences Influencing Panel Members' Perceptions of the Animal Systems Skills Needed by SBAE Teachers (n = 34)

Experience	*f* (%)
Experiences teaching agricultural education coursework	27 (79.4)
Experiences working in the agricultural industry	26 (76.5)
My experiences with FFA activities (e.g., CDE teams, etc.)	17 (50.0)
Teacher education program coursework	12 (34.3)
My experiences with student Supervised Agricultural Experiences (SAE)	12 (34.3)
Early field experiences / observations before student teaching	10 (29.4)
Attendance at professional development workshop sessions	10 (29.4)
Meetings with industry representatives	10 (29.4)
High school coursework as a student	9 (26.5)
Meetings with my current / former students	8 (23.5)
Meetings with other agricultural education teachers	8 (23.5)
Compliance with mandated course standards	5 (14.7)
Meetings with my program advisory committee members	4 (11.8)
Meetings with community members	3 (8.8)
Compliance with workforce development data	2 (5.9)
Meetings with parents / guardians	2 (5.9)
Meetings with other (non-agricultural education) teachers	2 (5.9)
Meetings with my school administrators	2 (5.9)

Conversely, "Meetings with parents / guardians" (*f* = 2; 5.9%), "Meetings with other (non-agricultural education) teachers" (*f* = 2; 5.9%), and "Meetings with my school administrators" (*f* = 2; 5.9%) were the experiences the fewest numbers of panelists perceived to influence their perceptions of the technical agriculture skills teachers need to teach courses in the Animal Systems pathway.

Round One

In round one of our study, the panelists provided us with 293 skill items. We removed any duplicate responses we received, yielding 99 unique skill items for consideration by the panelists during round two. Prior to distributing our second-round instrument, we grouped these items into nine categories to improve the readability of our second-round instrument.

Round Two

We used our second-round instrument to send the 99 skill items back to the panelists for review. Upon completion of the second round, 24 of the 99 skill items met consensus. Fifty-one to 74% of the panelists rated 55 skill items as a 5 (*Agree*) or 6 (*Strongly agree*). We used our third-round instrument to send these 55 skill items back to the panelists for review. Twenty items fell below the 51% threshold of the consensus criteria during the second round. We eliminated these 20 items from further consideration in round three.

Round Three

Our third-round instrument was comprised of 55 skill items. During the third round, the panelists reached consensus on 11 skill items. Forty-four skill items did not meet consensus and we thus removed them from our list. At the conclusion of our three-round Delphi study, 35 skill items met consensus among the panelists. We detailed the skill items that met consensus throughout rounds two and three in Table 3 below.

Table 3

Round Two and Three Findings: Animal Systems Skills Needed by SBAE Teachers

Skill Item	*n*	Category	% Agreement
Identifying animal species[a]	23	GAS	100.0
Procedures for using a microscope[b]	22	APB	95.7
Identifying external animal anatomy[a]	23	APB	95.6
Interpreting animal feed labels[b]	22	ANS	95.4
Keeping accurate animal records[a]	23	BCS	91.3
Procedures for safe animal handling tool and equipment use (ex. using squeeze chutes properly, etc.)[a]	23	AHR	91.3
Identifying various animal body systems and their components[a]	23	APB	91.3
Selecting appropriate housing for animals[b]	22	AMS	91.3
Identifying veterinary tools[ac]	22	AHC	90.9
Evaluating live animals[a]	23	GAS	87.0
Interpreting animal behavior[a]	23	GAS	87.0
Advocating for animal agriculture[a]	23	BCS	87.0
Sexing animals[a]	23	ARB	87.0
Identifying animal breeds[a]	23	GAS	86.9
Identifying tools and equipment used with animal handling[a]	23	AHR	86.9
Identifying animal feedstuffs[a]	23	ANS	86.9
Professionally communicating about animal agriculture to the public[a]	23	BCS	85.7
Performing profit / loss calculations for an animal enterprise[a]	23	BCS	82.6
Procedures for restraining large animals (ex. cattle, etc.)[a]	23	AHR	82.6
Calculating animal genetic probability (ex. using Punnett Squares, etc.)[a]	23	ARB	82.6
Interpreting veterinary medical terminology[b]	22	AHC	82.6
Performing veterinary calculations (ex. conversions, etc.)[b]	22	AHC	82.6
Calculating animal medication dosages[ac]	22	AHC	81.9
Performing an animal health check / physical exam[ac]	22	AHC	81.8
Interpreting animal medication labels[ac]	22	AHC	81.8
Administering animal vaccinations (ex. subcutaneous, etc.)[b]	22	AHC	78.3
Identifying wholesale cuts of meat[b]	22	APPM	78.3
Using the Pearson Square to formulate feed rations[b]	23	ANS	78.3
Professionally collaborating with colleagues and clients about animals[b]	22	BCS	78.3
Performing animal first aid[b]	22	AHC	78.3
Procedures for dissecting animals[b]	22	APB	78.2

Skill Item	*n*	Category	% Agreement
Safely handling hazardous materials[a]	23	GAS	78.2
Procedures for restraining small animals (ex. dogs, etc.) [a]	23	AHR	78.2
Collecting animal vital signs (ex. body temperature, etc.)[ac]	22	AHC	77.3
Identifying retail cuts of meat[ac]	22	APMM	77.3

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*.

Key for Skill Categories. (1) General Animal Systems skills = GAS, (2) Business and Communications skills = BCS, (3) Animal Handling and Restraint skills = AHR, (4) Animal Anatomy, Physiology, and Biology skills = APB, (5) Animal Reproduction and Breeding skills = ARB, (6) Animal Nutrition skills = ANS, (7) Animal Management skills = AMS, (8) Animal Health and Care skills = AHC, and (9) Animal Products, Processing, and Marketing skills = APPM.

Conclusions, Discussion, and Recommendations

We identified 35 technical agriculture skills teachers in Illinois and Iowa need to effectively teach courses in the Animal Systems pathway found within the broader AFNR Career Cluster as indicated by The Council (2015). Regarding the technical agriculture skills needed by SBAE teachers, our findings add to the body of knowledge presented by other scholars' recent works (i.e., Albritton & Roberts, 2020; Hainline & Wells, 2019; Swafford & Hagler, 2018; Wells et al., 2021).

We believe our list of 35 technical agriculture skills has implications for the teacher competence development process in Illinois and Iowa and are valuable to SBAE stakeholders in these states. Thus, we wish to share several practical recommendations these stakeholders should consider:

1) Use our list of technical agriculture skills to explore the development of professional development workshops targeted toward in-service teachers to facilitate continued professional growth and technical agriculture skill development;

2) Review current agricultural teacher education programs in these two states to examine and identify opportunities for pre-service teachers to learn technical agriculture skills relevant to courses in the Animal Systems pathway;

3) Engage with agricultural faculty (e.g., beef cattle nutritionists, swine reproductive physiologists, meat scientists) who teach technical agriculture coursework relevant to the Animal Systems pathway within undergraduate degree programs; and

4) Use our list of technical agriculture skills to further explore professional development needs through follow-up studies, similar to the approach used by Wells and Hainline (2021).

These efforts could help to better ensure that SBAE teachers in Illinois and Iowa are more prepared to competently teach technical agriculture skills to their own students.

Considering our recommendations, we recognize the difficulties and unpredictable variables that are sometimes present when charting the path of change. As SBAE students are expected to have a range of technical skills related to animal agriculture (Slusher et al., 2011), their teachers should likewise be prepared to teach them requisite technical agriculture skills as part of developing human capital for the agricultural industry. As noted by Stripling and Ricketts (2016), the agricultural industry needs a well-prepared workforce and SBAE teachers are an important part of developing individuals capable of working in the 21st century. Human capital development is an involved process that requires many inputs (Swanson & Holton, 2001), such as adequate training and opportunities for continuous, professional growth that in turn benefit a swath of people. The development of competent, prepared SBAE teachers is no different.

Whittington (2005) noted that multiple components contribute to the development of SBAE teachers. Thus, carefully-crafted strategies must be developed and implemented to help ensure teachers can competently teach technical agriculture skills to their own students. Agricultural teacher education programs can sometimes be difficult to alter due to an assortment of limiting factors, such as degree program credit hour limitations, obtaining the necessary permissions from state-level education departments, and resistance from colleagues. It is therefore necessary to consider practical, creative solutions to ensuring pre-service teachers can learn the requisite technical agricultural skills they need. Intentional, pragmatic early field experiences could be used as a method for improving teacher competence (Wells et al., 2018) in conjunction with high-quality student teaching experiences. In

addition, incorporating technical agriculture skill development-oriented activities into existing teaching methods courses could be suitable and cost-effective.

We collected data only from the current SBAE teachers in Illinois and Iowa who served as our panelists. Thus, we recognize that our results are not generalizable beyond these states or these panelists. To help combat these limitations, we recommend that scholars replicate our study in other areas of the United States. Doing so would add to the literature describing SBAE teachers' technical agriculture skill needs relevant to teaching courses in the Animal Systems pathway. Moreover, as also expressed by Wells et al. (2021), replication of our study at regular intervals of time would help SBAE stakeholders monitor for alterations in teachers' agricultural subject matter knowledge needs, which are a trait of effective SBAE teachers (Eck et al., 2019; Roberts & Dyer, 2004). Undertaking a national-level replication of our study would be valuable as well and would serve a broader body of SBAE stakeholders. Consideration should also be given to including animal agriculture industry stakeholders as panelists in future replications of our study. This approach would be similar to how Slusher et al. (2011) and Ramsey and Edwards (2011) conducted their respective studies and may yield deeper insights and perspectives regarding the technical agriculture skills teachers need to prepare their students for both college and career opportunities.

As the agricultural industry perpetually evolves to meet societal needs (Doerfert, 2011), it is imperative that SBAE stakeholders be as prepared as possible to make data-driven adaptations to the agricultural teacher education process. As expressed by Solomonson et al. (2018), teachers' *Lack of Confidence to Teach the Curriculum* (which includes teaching technical agriculture skills to students) is a primary contributor to teacher retention issues, which is an issue of utmost priority to our profession (Foster et al., 2020). It is important that we as agricultural teacher educators facilitate opportunities to help ensure pre-service teachers will be successful as they transition into their forthcoming professional roles.

References

Albritton, M. C., & Roberts, T. G. (2020). Agricultural technical skills needed by entry level agriculture teachers: A modified Delphi study. *Journal of Agricultural Education, 61*(1), 140-151. https://doi.org/10.5032/jae.2020.01140

Baye, M. R., & Prince, J. T. (2014). *Managerial economics and business strategy*. McGraw-Hill/Irwin.

Dalkey, N. C., Rourke, D. L., Lewis, R., & Snyder, D. (1972). *Studies in the quality of life*. Lexington Books.

Darling-Hammond, L. (2003). Keeping good teachers: Why it matters, what leaders can do. *Educational Leadership*, *60*(8), 7-13. Retrieved from http://www.ascd.org/publications/educational-leadership/may03/vol60/num08/Keeping-Good-Teachers@-Why-It-Matters,-What-Leaders-Can-Do.aspx

Darling-Hammond, L., Chung, R., & Frelow, F. (2002). Variation in teacher preparation: How well do different pathways prepare teachers to teach? *Journal of Teacher Education, 53*(4), 286-302. https://doi.org/ 10.1177/0022487102053004002

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). *Internet, phone, mail, and mixed-mode surveys: The tailored design method* (4th ed.). John Wiley & Sons.

Doerfert, D. L. (Ed.) (2011). *National research agenda: American Association for Agricultural Education research priority areas for 2011-2015*. Lubbock, TX: Texas Tech University, Department of Agricultural Education and Communications.

Easterly, R. G., III, & Myers, B. E. (2017). Characteristics of enthusiastic and growing school-based agricultural education teachers: A Delphi approach. *Journal of Agricultural Education, 58*(2), 1-19. https://doi.org/10.5032/jae.2017.02001

Eck, C. J., Robinson, J. S., Ramsey, J. W., & Cole, K. L. (2019). Identifying the characteristics of an effective agricultural education teacher: A national study. *Journal of Agricultural Education, 60*(4), 1-18. https://doi.org/10.5032/jae.2019.04001

Foster, D. D., Lawver, R. G., & Smith, A. R. (2020). *National agricultural education supply & demand study: 2019 executive summary*. https://aaaeonline.org/resources/Documents/NSD2019%20Summary_7.15.20.pdf

Hainline, M. S., Burris, S., Ulmer, J. D., & Ritz, R. A. (2019). School district superintendents' and attorneys' perceptions of the most important educational law issues impacting agricultural science teachers. *Journal of Agricultural Education, 60*(2), 190-209. https://doi.org/10.5032/jae.2019.02190

Hainline, M. S., & Wells, T. (2019). Identifying the agricultural mechanics knowledge and skills needed by Iowa school-based agricultural education teachers. *Journal of Agricultural Education, 60*(1), 59-79. https://doi.org/10.5032/jae.2019.01059

Hasson, F., & Keeney, S. (2011). Enhancing rigour in the Delphi technique research. *Technological Forecasting and Social Change*, *78*(9), 1695-1704. https://doi.org/10.1016/j.techfore.2011.04.005

Haynes, M. (2014). *On the path to equity: Improving the effectiveness of beginning teachers.* https://all4ed.org/reports-factsheets/path-to-equity

Hendrix, R., & Morrison, C. C. (2018). Student perceptions of workforce readiness in agriculture. *Journal of Agricultural Education, 59*(3), 213-228. https://doi.org/10.5032/jae.2018.03213

Ingersoll, R. & Smith, T. (2003). The wrong solution to the teacher shortage. *Educational Leadership 60*(8), 30-33.

Linstone, H. A., & Turoff, M. (Ed.). (1975). *The Delphi method: Techniques and applications*. Addison Wesley Publishing Company.

Love, T. S. (2013). Addressing safety and liability in STEM education: A review of important legal issues and case law. *The Journal of Technology Studies, 39*(1), 28-42. https://doi.org/10.21061/jots.v39i1.a.3

Lutz, W., & KC, S. (2011). Global human capital: Integrating education and population. *Science, 333*(6042), 587-592. doi:10.1126/science.1206964

McDaniel, T. R. (2020). Corporal punishment and teacher liability: Questions teachers ask. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 93*(2), 10-13. https://doi.org10.1080/00098655.2020.1729640

The National Council for Agricultural Education (2015). *AFNR career cluster content standards*. https://ffa.app.box.com/s/n6jfkamfof0spttqjvhddzolyevpo3qn/file/294160068843

Phipps, L. J., Osborne, E. W., Dyer, J. E., & Ball, A. (2008). *Handbook on agricultural education in public schools* (6th ed.). Thomson Delmar Learning.

Ramsey, J. W., & Edwards, M. C. (2011). Entry–level technical skills that agricultural industry experts expected students to learn through their supervised agricultural experiences: A modified Delphi study. *Journal of Agricultural Education, 52*(2), 82-94. https://doi.org/10.5032/jae.2011.02082

Ramsey, J. W., & Edwards, M. C. (2012). Entry–level technical skills that teachers expected students to learn through supervised agricultural experiences (SAEs): A modified Delphi study. *Journal of Agricultural Education, 53*(3), 42-55. https://doi.org/10.5032/jae.2012.03042

Rinker, S. P., Smalley, S. W., & Hainline, M. S. (2021). Identifying the professional and technical skills agricultural industry employers expect agricultural graduates to possess. *NACTA Journal, 65*(1), 102-114.

Roberts, T. G., & Ball, A. L. (2009). Secondary agricultural science as content and context for teaching. *Journal of Agricultural Education, 50*(1), 81-91. https://doi.org/10.5032/jae2009.01081

Roberts, T. G., & Dyer, J. E. (2004). Characteristics of effective agriculture teachers. *Journal of Agricultural Education, 45*(4), 82-95. http://doi.org/10.5032/jae.2004.04082

Robinson, J. S., & Baker, M. A. (2013). The effect of human capital on principals' decisions to interview candidates in agricultural education: Implications for pre-service teachers. *Journal of Agricultural Education, 54*(1), 139-152. http://doi.org/10.5032/jae.2013.01139

Robinson, J. S., & Garton, B. L. (2008). An assessment of the employability skills needed by graduates in the college of agriculture, food and natural resources at the University of Missouri. *Journal of Agricultural Education, 49*(4), 96-105. https://doi.org/10.5032/jae.2008.04096

Saucier, P. R., Vincent, S. K., & Anderson, R. G. (2014). Laboratory safety needs of Kentucky school-based agricultural mechanics teachers. *Journal of Agricultural Education, 55*(2), 184- 200. https://doi.org/10.5032/jae.2014.02184

Sharkey, S. B., & Sharples, A. Y. (2001). An approach to consensus building using the Delphi technique: Developing a learning resource in mental health. *Nurse Education Today*, *21*(5), 398-408. https://doi.org/10.1054/nedt.2001.0573

Shoulders, C. W., & Myers, B. E. (2012). Teachers' use of agricultural laboratories in secondary agricultural education. *Journal of Agricultural Education, 53*(2), 124-138. https://doi.org/10.5032/jae.2012.02124

Slusher, W. L., Robinson, J. S., & Edwards, M. C. (2011). Assessing the animal science technical skills needed by secondary agricultural education graduates for employment in the animal industries: A modified Delphi study. *Journal of Agricultural Education, 52*(2), 95-106. https://doi.org/10.5032/jae.2011.02095

Solomonson, J. K., Korte, D. S., Thieman, E. B., Retallick, M. S., & Keating, K. H. (2018). Factors contributing to Illinois school-based agriculture teachers' final decision to leave the classroom. *Journal of Agricultural Education*, *59*(2), 321-342. https://doi.org/10.5032/jae.2018.02321

Stitt-Gohdes, W. L., & Crews, T. B. (2004). The Delphi technique: A research strategy for career and technical education. *Journal of Career and Technical Education, 20*(2), 55-67. https://files.eric.ed.gov/fulltext/EJ1069510.pdf

Stripling, C. T., & Ricketts, J. C. (2016). Research priority 3: Sufficient scientific and professional workforce that addresses the challenges of the 21st century. In T. G. Roberts, A. Harder, & M. T. Brashears. (Eds.), *American Association for Agricultural Education national research agenda: 2016-2020.* Department of Agricultural Education and Communication.

Swafford, M., & Hagler, P. (2018). Beginning SBAE teachers' metal fabrication knowledge needs: Implications for teacher preparation. *Journal of Agricultural Education, 59*(1), 287-296. https://doi.org/10.5032/jae.2018.01287

Swanson, R. A., & Holton, E. F. (2001). *Foundations of human resource development* (2nd ed.). Berrett-Kohler.

Sweetland, S. R. (1996). Human capital theory: Foundations of a field of inquiry. *Review of Educational Research, 66*(3), 341-359. doi:10.3102/00346543066003341

Twenter, J. P., & Edwards, M. C. (2017). Facilities in school-based, agricultural education (SBAE): A historical inquiry. *Journal of Agricultural Education, 58*(3), 275-292. https://doi.org/10.5032/jae.2017.03275

Wells, T., & Hainline, M. S. (2021). Examining teachers' agricultural mechanics professional development needs: A national study. *Journal of Agricultural Education, 62*(2), 217-238. https://doi.org/10.5032/jae.2021.02217

Wells, T., Hainline, M. S., Rank, B. D., Sanders, K. W., & Chumbley, S. B. (2021). A regional study of the agricultural mechanics knowledge and skills needed by school-based agricultural education teachers. *Journal of Agricultural Education, 62*(2), 148-166. https://doi.org/10.5032/jae.2021.02148

Wells, T., Smalley, S. W., & Rank, B. D. (2018). Early field experience course students' perceptions of school-based agricultural education laboratory environments. *Journal of Agricultural Education, 59*(3), 243-257. https://doi.org/10.5032/jae.2018.03243

Whittington, M. S. (2005). The presidential address to the Association for Career and Technical Education Research: Using standards to reform teacher preparation in career and technical education: A successful reformation. *Career and Technical Education Research, 30*(2), 89-99. https://www.ctc.ca.gov/docs/default-source/educator-prep/cte-files/cte-research-presidential-address.pdf

Williams, P. L., & Webb, C. (1994). The Delphi technique: A methodological discussion. *Journal of Advanced Nursing*, *19*(1), 180-186. https://doi.org/10.1111/j.1365-2648.1994.tb01066.x

Woudenberg, F. (1991). An evaluation of Delphi. *Technological Forecasting and Social Change, 40*(1), 131-150. https://doi.org/10.1016/0040-1625(91)90002-W

Yousuf, M. I. (2007). Using experts' opinions through Delphi technique. *Practical Assessment, Research, and Evaluation*, *12*(1), 1-8. https://doi.org/10.7275/rrph-t210

Zirkle, C. (2017). An introduction to liability for technology and engineering teachers. *Technology and Engineering Teacher, 76*(7). https://www.questia.com/library/journal/1G1- 499277882/an-introduction-to-liability-for-technology-and-engineering