

Agricultural Mechanics Training Deficits among Preservice School-Based Agricultural Education Teachers: An Assessment of Teacher Educators' Perceptions

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Abstract

Agricultural mechanics has become a common yet highly technical component of modern school-based agricultural education (SBAE). Despite the prevalence of agricultural mechanics in secondary agriculture instruction, deficits in training have been prominent in the literature. To meet the workforce needs of agricultural industries, SBAE teachers must be adequately prepared with knowledge and skills to impart on their students. To prioritize agricultural mechanics competencies for preservice SBAE teachers, we used the ranked discrepancy model to examine SBAE teacher educators' perceptions of importance and level of preparation in 59 agricultural mechanics competencies. We found that all competencies in the study displayed some degree of training deficit. Our findings also indicated that the greatest training deficits were related to agricultural machinery and equipment and renewable energy, particularly in areas of recent technological advancement. Conversely, we observed the smallest training deficits in competencies related to metal fabrication, outdoor power equipment, and small engines. We recommend that SBAE teacher educators use these findings to better facilitate targeted professional development for agricultural mechanics. We also call for future needs assessments in agricultural mechanics to consider using the ranked discrepancy model.

Introduction

Agricultural mechanics has been defined as “the design, construction, maintenance, repair, management, and use of agricultural technology and mechanical systems” (Hancock et al., 2017, p. 4) and is a prominent content area within school-based agricultural education (SBAE). Considering that the most common form of SBAE laboratory is an agricultural mechanics facility, this prominence is to be expected (Shoulders & Myers, 2012). Under many different names, agricultural mechanics content has been present in SBAE in the U.S. since its inception (Twenter & Edwards, 2017). The importance placed on agricultural mechanics as a component of SBAE is in part due to the amount of time many teachers have dedicated to agricultural mechanics-related instruction, which has stayed consistently high over time (Hoerner & Beckham, 1990; McKim & Saucier, 2011; Saucier et al., 2014). Based on the amount of instructional time commonly devoted to agricultural mechanics in SBAE, it is conceivable that the largest set of technical

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skills deemed necessary for new SBAE teachers align with the agricultural mechanics content area (Albritton & Roberts, 2020).

Agricultural industries have grown and developed in technical complexity, as has the demand for employees familiar with agricultural mechanical and technical systems (Hancock et al., 2017). Originally, SBAE instruction in agricultural mechanics was designed to train students in operating, maintaining, and repairing farm equipment that they were likely to encounter as farmers and ranchers (Twenter & Edwards, 2017). However, as agricultural production systems diversified, agricultural mechanics education adapted to include skillsets beyond production machinery, as it was anticipated that SBAE students would need a technical aptitude for both on and off-farm applications (Twenter & Edwards, 2017).

Agricultural mechanics at the secondary level also has post-secondary implications for students. Participation in an agricultural mechanics summer educational program has been shown to positively impact high school students' self-efficacy in agricultural mechanics skills and their consideration of teaching agricultural mechanics as a career (Gorter & Swan, 2018). Similarly, Rasty et al. (2017) concluded that agricultural mechanics training at the secondary level influenced SBAE teachers' perceptions of the importance of teaching agricultural mechanics skills. In a continuation of the work by Rasty et al. (2017), Mills et al. (2019) found statistically significant and positive relationships between secondary training and teacher competence in 53 of 54 agricultural mechanics competencies. Further, Wells et al. (2013) reported a statistically significant and positive relationship between Iowa preservice SBAE teachers' amount of agricultural mechanics training received at the secondary level and intentions to enroll in post-secondary agricultural mechanics coursework.

Preparation of Preservice Teachers in Agricultural Mechanics

Enrollment in agricultural mechanics courses in SBAE has traditionally trended high (Burriss et al., 2005). Further, agricultural mechanics knowledge was featured as a primary content area in a study designed to examine the content knowledge held by successful SBAE teachers (Roberts et al., 2007). Additionally, as reported by Albritton and Roberts (2020), over one-third of the skills perceived as necessary for new teachers in SBAE were related to agricultural mechanics. The necessity of these skills has not gone unnoticed by agricultural education undergraduates, as mentions of agricultural mechanics as a necessary knowledge area for teaching SBAE were common in early field experience reflections (Baker et al., 2017; Wells et al., 2018). Similarly, the *Standards for SBAE Teacher Preparation Programs* (American Association for Agricultural Education [AAAE], 2017) emphasized knowledge and skills related to agricultural equipment among the knowledge and performance indicators associated with *Technical Content Knowledge*, one of the six primary standards comprising the document. As such, training in agricultural mechanics has traditionally been an area of importance in SBAE teacher education.

A study by Breeding et al. (2018) found that winners of the National Association of Agricultural Educators' Outstanding Young Member award did not feel strongly prepared to teach agricultural mechanics through their SBAE teacher preparation programs. Similarly, Wells et al. (2021a) concluded that preservice teachers in several states were not adequately prepared to implement agricultural mechanics content. In reviewing the preparation of preservice SBAE teachers in agricultural mechanics, Hubert and Leising (2000) found that in the mid-1990s, an average of 6.7 agricultural mechanics course credits were required for certification among teacher preparation programs in the United States. A similar examination published five years later indicated that nearly 90% required multiple course credits in agricultural mechanics content, with an average requirement of 9.1 credits (Burriss et al., 2005). Subsequent studies, however, have suggested that the number of required credits may have decreased as teacher preparation programs conform to shortened degree completion timelines (Byrd et al., 2015; Johnson et al., 2012; McKim & Saucier, 2013). More recently, two studies confirmed reductions in the number of agricultural mechanics credit hours, with a reported national average of 5.8 required credit hours (Granberry et al., 2023; Trickett et al., 2023).

Beyond the influence of related coursework, researchers have also investigated preservice teachers' perceptions of agricultural mechanics. In a qualitative study of final-year preservice female teachers, Tummons et al. (2017) found that students held concerns about student safety, credibility, and skill acquisition. Similar findings of anxiety and concerns about technical knowledge have been noted among younger female agricultural education undergraduates (Granberry et al., 2022). Outside the bounds of gender, Hainline et al. (2018) described a case of preservice teachers in Texas with self-efficacy concerns stemming from a lack of knowledge, experience, and opportunity to teach agricultural mechanics content. These findings align with an observed lack of self-efficacy in agricultural mechanics skills among preservice teachers over time (Blackburn et al., 2015). Additionally, deficits in skills related to instruction in agricultural mechanics, like maintenance and repair of equipment and safe laboratory management, have been reported among preservice SBAE teachers (Saucier & McKim, 2011).

Despite these concerns, research has indicated that enrollment in agricultural mechanics courses at the post-secondary level positively impacts content knowledge and perceptions of teaching outcomes in agricultural mechanics (Blackburn et al., 2015; Leiby et al., 2013; Whitehair et al., 2020). Conversely, the need for professional development in agricultural mechanics has been sustained in the literature for many years, which aligns with McKim and Saucier's (2013) findings of negligible change over 20 years in perceptions of ability in 22 of 33 agricultural mechanics laboratory management competencies in a study of Missouri SBAE teachers. More recent studies have also described the breadth of SBAE teachers' agricultural mechanics training needs in Alabama (Clemons et al., 2018), Iowa (Smalley et al., 2019), Montana (Toft et al., 2021), Arkansas, Louisiana, Oklahoma, and Texas (Wells et al., 2021a), as well as on a national scale (Wells & Hainline, 2021).

Conceptual Framework

We grounded this study in human capital theory (HCT) (Goode, 1959). According to HCT, a knowledgeable and skilled workforce is critical to maintaining a productive society (Becker, 1993). A primary resource in developing human capital is an educational system that can effectively produce highly trained personnel to support developing industries (Goode, 1959). Today, students can anticipate career opportunities in agricultural mechanics-based career pathways in many facets of modern agricultural industries (Hancock et al., 2017). In agricultural engineering alone, the Bureau of Labor Statistics (2021) anticipated a 5% increase in job growth between 2020 and 2030.

To reflect the diversity of these career opportunities for secondary students, the Agricultural, Food, and Natural Resources (AFNR) Career Pathway Content Standards for Power, Structural, and Technical Systems (PSTS) displayed a wide range of competencies and skills divided into six primary areas of study: Power and Machine Mechanics, Agricultural Structures, Welding and Metalwork, Electrical Power and Processes, Environmental Systems, and Tool and Equipment Safety (Koel et al., 2013; National Council for Agricultural Education [NCAE], 2015). In this study, HCT supported the concept that SBAE teacher preparation in agricultural mechanic systems and technology must be sufficient to supply a skilled and knowledgeable workforce. This concept was also supported by Byrd et al. (2020), who found that guided by a skilled instructor and dedicated curriculum, students in secondary agricultural mechanics courses displayed an aptitude for fabricating agricultural equipment according to industry-standard blueprints.

Technological Advancements in Agricultural Mechanics Education

The rapid growth of technology in agriculture necessitates education in agricultural mechanics to keep pace (Hancock et al., 2017). Precision agriculture, engineering, mechanization, and technological advancements are influential areas in the agricultural industry (Warren-English et al., 2019; Alston et al., 2018). Similarly, outdoor power equipment dealers recognize technology advancements as influential in their industry's future (Alston et al., 2018).

Computer Numerical Control (CNC) equipment and Computer-Aided Design (CAD) software have become prevalent in SBAE agricultural mechanics laboratories (Saucier & Langley, 2017). Interacting with CNC equipment provides experiential learning opportunities for students, aligning with industry careers (Rasty, 2020). STEM-centered professional development addresses SBAE teachers' needs in incorporating CNC technologies meaningfully (Saucier & Langley, 2017).

Renewable energy sources, including solar, wind, and biofuels, are emerging topics in agricultural mechanics education (Franklin, 2020). Agricultural mechanics instruction provides an ideal environment for delivering renewable energy education (Acker et al., 2008); however, teacher knowledge and training deficits hinder the implementation of renewable energy education (Paulsen et al., 2014). Professional development positively impacts teaching self-efficacy and outcome expectancy for renewable energy content, and SBAE teachers have expressed a desire for related training (Han & Martin, 2015; Paulsen et al., 2014).

Studies on SBAE teachers in Alabama and Iowa revealed a high demand for professional development to integrate current agricultural technology into the curriculum (Clemons et al., 2018; Smalley et al., 2019). Michigan SBAE teachers identified unmanned aerial vehicles and precision agriculture sensors as top emerging technologies requiring training (King et al., 2019). However, integration challenges persist, with limited content incorporation reported in Illinois and Alabama SBAE curricula (Heidenreich et al., 2020). This limited integration may be the result of teachers' tendency to acquire technology training through personal trial and error, often facing barriers like cost (Williams et al., 2014). When viewed through the lens of HCT, gaps in SBAE teacher training and education of emerging agriculture technologies may lead to deficits in a knowledgeable and skilled workforce.

Purpose and Objectives

The purpose of this study was to describe the agricultural mechanics training needs of preservice SBAE teachers as perceived by SBAE teacher educators. This study is one component of a larger research effort on the preparation of preservice SBAE teachers in agricultural mechanics. This work aligns with the AAAE Research Values related to *increasing prosperity through innovation in AFNR systems* by examining training needs for SBAE teachers to aid in developing the future AFNR workforce (AAAE, 2023). The following three objectives guided our study:

1. Determine SBAE preservice teachers' agricultural mechanics training deficits as perceived by teacher educators.
2. Rank the largest agricultural mechanics training deficits for preservice SBAE teachers.
3. Rank the smallest agricultural mechanics training deficits for preservice SBAE teachers.

Methods

This descriptive study sought to examine the priority of agricultural mechanics competencies for preservice SBAE teachers based on the perceptions of teacher educators. We focused on a target population of one teacher educator from every post-secondary institution in the United States, offering four-year undergraduate degree programs designed to train SBAE teachers. The target population comprised institutions listed as AAAE members, with a frame of reference provided by Kleinjan and Marx (2018). A panel of teacher educators reviewed the list for frame errors, excluding any institutions that did not meet the study's criteria. Additionally, 11 institutions that were not on the AAAE list but met the inclusion criteria were added, resulting in a final target population of 98 institutions.

Dillman et al. (2014) posited that a census is appropriate in cases where the population is small and surveying everyone incurs negligible additional costs. Given the manageable size of the target population, we utilized online faculty directories to identify a representative for each institution and conducted a census

via a Qualtrics survey using the tailored design method (Dillman et al., 2014). These representatives, confirmed by a panel of current SBAE teacher educators, were chosen based on their role as faculty members in the SBAE teacher preparation program and their involvement in courses related to agricultural mechanics topics or laboratory management. In cases in which we could not identify a representative meeting both criteria, we selected an SBAE teacher educator at the institution. If we did not find any agricultural education faculty, we instead chose the chair of the department housing the SBAE teacher preparation program to represent the institution. When data collection concluded, 77 participants provided data usable for analysis, comprising a response rate of 78.6%. To address non-response, we made multiple attempts to contact non-respondents. If no survey data could be collected, demographic information about non-responding institutions was collected from their respective websites to help us identify any noticeable trend in non-respondents. Based on the demographic data, we determined that this study may not adequately represent private colleges or universities with undergraduate enrollments below 3,000 students in the North Central AAE region.

For this study, we used an updated version of an instrument by Burris et al. (2005), who provided respondents with a list of competencies in the following content areas: (a) *Metal Fabrication*, (b) *Hand and Power Tools*, (c) *Project Planning and Materials Selection*, (d) *Electricity*, (e) *Concrete*, (f) *Plumbing*, (g) *Building Construction*, (h) *Ag Power* (renamed *Outdoor Power Equipment and Small Engines*), and (i) *Machinery and Equipment*. We retained the original instrument's competencies but reworded several for clarity. Additionally, we included new competencies where necessary to reflect modern technology in agricultural mechanics. We derived new competencies from the Power, Structural, and Technical System Pathway in the AFNR Standards from The NCAE (2015) and state standards available to the public. The inclusion of updated competencies also necessitated the creation of a new content area: *renewable energy*. The resulting instrument consisted of 59 competencies across the ten content areas, found in Table 1.

Table 1

Agricultural Mechanics Competency Groups and Competencies Included in the Instrument

Competency Groups	Competencies
Metal Fabrication	Identify types of metal
	Cut, file, shape, and drill metal
	Operate electric arc welding equipment
	Demonstrate out-of-position welding
	Operate oxy-acetylene equipment
	Operate plasma cutting equipment
	Use computer numerical control (CNC) cutting systems
Apply safety practices associated with metal fabrication	
Hand and Portable Power Tools	Use hand and portable power tools
	Use measuring and marking devices
	Demonstrate procedures for reconditioning and sharpening common hand tools
	Apply safety practices for using hand and portable power tools
Project Planning and Material Selection	Interpret designs and sketches
	Utilize computer-aided design (CAD) software programs
	Estimate materials cost for project construction
	Develop working drawings
	Prepare a bill of materials
	Demonstrate the layout process for project construction
Demonstrate the proper selection of paint and preservatives	

Competency Groups	Competencies
Electricity	<ul style="list-style-type: none"> Identify the basic principles of electrical wiring Identify symbols used in agricultural wiring plans Estimate electrical loads and circuit needs Select wiring materials and supplies Perform basic electrical wiring skills Replace electric motors Apply safety practices associated with electricity
Concrete	<ul style="list-style-type: none"> Estimate materials Construct forms and reinforcing structures Place, finish, and cure concrete Apply safety practices associated with concrete
Plumbing	<ul style="list-style-type: none"> Identify plumbing equipment Install pipe and plumbing fixtures Maintain water systems Apply safety practices associated with plumbing
Building Construction	<ul style="list-style-type: none"> Plan cost-effective construction Identify building materials Apply basic carpentry skills Select and use wood and metal fasteners Install framing, doors, windows, and roofing Use land surveying equipment Apply safety practices associated with building construction
Outdoor Power Equipment and Small Engines	<ul style="list-style-type: none"> Describe the principles of operation for internal combustion engines Troubleshoot problems with small gasoline engines Diagnose power system conditions Service and repair small gasoline engines Disassemble and reassemble small gasoline engines Apply safety practices associated with outdoor power equipment
Machinery and Equipment	<ul style="list-style-type: none"> Explain the basic principles of operation of agricultural power and machinery systems Operate agricultural machinery and equipment Perform maintenance and repairs on agricultural machinery and equipment Explain the use of electronic instrumentation (guidance systems, monitors, on-board computers, and sensors) Service monitoring, sensing, and metering devices Explain the use of unmanned aerial vehicles (UAV/drones) in agricultural production Apply safety practices associated with agricultural machinery and equipment
Renewable Energy	<ul style="list-style-type: none"> Install solar photovoltaic system components Maintain and repair solar photovoltaic system components Explain the use of wind turbines for energy generation Explain the production of biofuels Apply safety practices associated with renewable energy systems

We asked participants to rate their perception of each competency's importance on a five-point Likert-type scale, with one indicating the lowest level of importance and five indicating the highest. Further, we asked participants to indicate their perception of the level of preparation that preservice SBAE teachers in their programs received on those same competencies using a similar five-point Likert-type scale. Cronbach's (1951) alpha was used to calculate the *post hoc* reliability of the scales used to measure perceived levels of importance and preparation in agricultural mechanics competencies. Alpha values for scale items ranged from .83 to .96.

Ranked Discrepancy Model

We selected Narine and Harder's (2021) ranked discrepancy model (RDM) to assess teacher educators' perceptions of preservice teachers' agricultural mechanics training needs. Narine and Harder (2021) proposed the RDM as an alternative to the Borich (1980) needs assessment model, addressing issues of scale interpretation and comparability between studies.

The RDM is appropriate under specific conditions, including cross-sectional data gathered from a target population at a single point in time, paired ordinal scales for each variable, and a focus on assessing discrepancies between two identified conditions for each item, all of which align with the data collected for this study (Narine & Harder, 2021). Analyzing results using both the Borich model and the RDM, Narine and Harder (2021) found a very strong and positive correlation ($r = 0.98$) and minor differences in competency rankings.

The calculation of ranked discrepancy scores involved counting negative ranks (NR), positive ranks (PR) and tied ranks (TR) using Wilcoxon's signed rank test in IBM SPSS version 27 (Field, 2018; Narine & Harder, 2021). Negative ranks represented competencies perceived as more important than the preparation of preservice teachers, while positive ranks indicated the opposite. Tied ranks reflected equal perceptions of importance and preservice teachers' preparation in a competency.

After performing Wilcoxon's (1945) signed rank test, we transferred the SPSS output to a Microsoft Excel-based RDS calculator derived from Narine and Harder's (2021) instructions. We then weighted the rank percentages to produce the final RDS for each competency. Negative rank percentages were multiplied by -1, positive rank percentages by 1, and tied ranks by 0. The sum of weighted rank percentages yielded an RDS ranging from -100 to 100. Negative values indicated a need for training, while positive values suggested above-adequate preparation. In the case of competencies with equal RDS, we determined the rankings by the largest percentage of negative ranks, followed by mean average importance where necessary. We then reordered the list of competencies by RDS to identify the largest and smallest deficits.

Findings

For this investigation, we drew upon teacher educators' perceptions of competencies collected in our larger study to identify the agricultural mechanics training needs of preservice SBAE teachers using Narine and Harder's (2021) RDM. We present our findings below by the research objective they address.

Objective One: Determine SBAE preservice teachers' agricultural mechanics training deficits as perceived by teacher educators.

All agricultural mechanics competencies displayed negative ranks (NR), indicating that the perceived level of importance of the competency was greater than the perceived level of preparation that preservice teachers were receiving. The NR for all competencies ranged from 32.89% to 72.68% of respondents. Additionally, 36 of the 59 competencies had NR, comprising over 50% of respondents. Conversely, 53 of the 59 competencies had some instances of positive ranks (PR), meaning that some respondents perceived that their students were better prepared for those competencies than their perceptions of importance necessitated. The highest PR percentage was 11.69% of respondents in *operating oxy-*

acetylene cutting equipment. All competencies exhibited tied ranks (TR), indicating that respondents perceived their students to be adequately prepared based on the importance of the competency. The percentage of tied ranks ranged from a minimum of 25% of respondents on *servicing monitoring, sensing, and metering devices* to a maximum of 64.47% of respondents on *applying safety practices associated with outdoor power equipment*.

The real values for RDS were -100 to 100, with negative values indicating a need for training. Our findings revealed that all 59 agricultural mechanics competencies displayed a negative RDS, indicating at least some need for training. RDS values for all competencies ranged from -72.37 to -25.00.

Objective Two: Rank the largest agricultural mechanics training deficits for preservice SBAE teachers.

The competency group with the greatest number of individual competencies in the top quarter of the ranking was *machinery and equipment*, with five of its seven competencies indicating a high need for training in this area. *Renewable energy* followed closely, with four of its five competencies in the top 25%. *Concrete* had two of its four competencies near the top of the rankings, followed by metal fabrication, project planning and materials selection, plumbing, and building construction, with one competency each in the top 25%.

The five highest-ranked competencies in terms of greatest training needs were *service monitoring, sensing, and metering devices* (RDS = -72.37), *explain the use of electronic instrumentation* (RDS = -71.05), *use CNC cutting systems* (RDS = -68.42), *operate agricultural machinery and equipment* (RDS = -67.11), and *utilize CAD software* (RDS = -64.47). The sixth-ranked competency, *maintain and repair solar photovoltaic system components* (RDS = -64.47), exhibited an equal RDS and equal percentages of NR, PR, and TR. In this case, we used average perceived importance to establish the ranking. The competencies with the lowest RDS, indicating the greatest need for training, are ranked in Table 2 below.

Table 2

Largest Agricultural Mechanics Training Deficits for Preservice SBAE Teachers Identified by Teacher Educators (n = 77)

Competency	Ranks (%)				Rank
	NR	PR	TR	RDS	
Service monitoring, sensing, and metering devices	73.68	1.32	25.00	-72.37	1
Explain the use of electronic instrumentation	71.05	0.00	28.95	-71.05	2
Use computer numerical control (CNC) cutting systems	69.74	1.32	28.95	-68.42	3
Operate agricultural machinery and equipment	67.11	0.00	32.89	-67.11	4
Utilize computer-aided design (CAD) software	65.79	1.32	32.89	-64.47	5 ^a
Maintain and repair solar photovoltaic system components	65.79	1.32	32.89	-64.47	6 ^a
Install solar photovoltaic equipment	63.16	1.32	35.53	-61.84	7
Estimate materials (concrete)	63.64	2.60	33.77	-61.04	8
Explain the production of biofuels	63.51	2.70	33.78	-60.81	9
Explain the use of wind turbines for energy generation	63.16	2.63	34.21	-60.53	10
Explain the use of UAV/drones in ag production	64.47	5.26	30.26	-59.21	11
Construct forms and reinforcing structures	61.04	2.60	36.36	-58.44	12 ^a
Install pipe and plumbing fixtures	59.74	1.30	38.96	-58.44	13 ^a
Perform maintenance and repairs on agricultural machinery and equipment	57.89	0.00	42.11	-57.89	14
Plan cost-effective construction	60.00	2.67	37.33	-57.33	15 ^a

Competency	Ranks (%)				Rank
	NR	PR	TR	RDS	
Apply safety practices associated with agricultural machinery and equipment	57.33	0.00	42.67	-57.33	16 ^a
Replace electric motors	58.44	1.30	40.26	-57.14	17
Apply safety practices associated with concrete	58.44	2.60	38.96	-55.84	18
Install framing, doors, windows, and roofing	57.89	2.63	39.47	-55.26	19 ^a
Explain the basic principles of operation of agricultural power and machinery systems	55.26	0.00	44.74	-55.26	20 ^a
Maintain water systems	57.14	2.60	40.26	-54.55	21
Place, finish, and cure concrete	57.89	3.95	38.16	-53.95	22
Estimate electrical loads and circuit needs	54.67	1.33	44.00	-53.33	23
Identify plumbing equipment	53.25	1.30	45.45	-51.95	24
Apply basic carpentry skills	55.26	3.95	40.79	-51.32	25 ^a
Apply safety practices associated with renewable energy	53.95	2.63	43.42	-51.32	26 ^a
Apply safety practices associated with plumbing	51.95	2.60	45.45	-49.35	27 ^a
Develop working drawings	51.95	2.60	45.45	-49.35	28 ^a
Interpret designs and sketches	52.00	2.67	45.33	-49.33	29
Troubleshoot problems with small gasoline engines	51.32	2.63	46.05	-48.68	30 ^a
Identify building materials	48.68	0.00	51.32	-48.68	31 ^a

Note: NR = Negative Ranks; PR = Positive Ranks; TR = Tied Ranks; RDS = Ranked Discrepancy Score;

^a Formula used to rank tied RDS scores.

Objective Three: Rank the smallest agricultural mechanics training deficits for preservice SBAE teachers.

The competency group with the most individual competencies in the bottom quarter of the ranking was *metal fabrication*, with four of its eight competencies indicating a lesser need for training compared to other areas. *Outdoor power equipment and small engines* and *hand and portable power tools* each had three competencies near the bottom of the list, followed by *project planning and material selection* and *electricity*, with two competencies each. *Building construction* was the final competency group represented in the bottom 25% with one competency, *prepare a bill of materials* ranked 48th.

The five lowest-ranked competencies, indicating the least need for additional training, were *disassemble and reassemble small gasoline engines* (RDS = -25.00), *cut, file, drill, and shape metal* (RDS = -26.32), *operate oxy-acetylene equipment* (RDS = -29.87), *apply safety practices for using hand and portable power tools* (RDS = -31.17), and *perform basic electrical wiring skills* (RDS = -32.47). It is important to note that although these competencies represent the bottom of the ranking in terms of the need for training, all have a negative RDS, indicating some need for training overall. The competencies that comprise the bottom half of the list, indicating a lesser need for training when compared to the upper half, are ranked by ascending RDS in Table 3.

Table 3

Smallest Agricultural Mechanics Training Deficits for Preservice SBAE Teachers Identified by Teacher Educators (n = 77)

Competency	Ranks (%)				Rank
	NR	PR	TR	RDS	
Disassemble and reassemble small gasoline engines	32.89	7.89	59.21	-25.00	59
Cut, file, drill, and shape metal	36.84	10.53	52.63	-26.32	58
Operate oxy-acetylene equipment	41.56	11.69	46.75	-29.87	57
Apply safety practices for using hand and portable power tools	35.06	3.90	61.04	-31.17	56
Perform basic electrical wiring skills	35.06	2.60	62.34	-32.47	55
Apply safety practices associated with outdoor power equipment	34.21	1.32	64.47	-32.89	54 ^a
Describe the principles of operation for internal combustion engines	38.16	5.26	56.58	-32.89	53 ^a
Apply the safety practices associated with metal fabrication	37.66	2.60	59.74	-35.06	52
Use hand and portable power tools	42.86	6.49	50.65	-36.36	51
Operate electric arc welding equipment	45.45	7.79	46.75	-37.66	50
Apply safety practices associated with electricity	40.79	1.32	57.89	-39.47	49
Prepare a bill of materials	44.16	3.90	51.95	-40.26	48 ^a
Use measuring and marking devices	45.45	5.19	49.35	-40.26	47 ^a
Apply safety practices associated with building construction	42.11	1.32	56.58	-40.79	46 ^a
Demonstrate the layout process for project construction	44.74	3.95	51.32	-40.79	45 ^a
Use land surveying equipment	52.63	10.53	36.84	-42.11	44
Operate plasma cutting equipment	49.35	6.49	44.16	-42.86	43 ^a
Demonstrate the proper selection of paint and preservatives	50.65	7.79	41.56	-42.86	42 ^a
Demonstrate procedures for reconditioning and sharpening common hand tools	51.95	9.09	38.96	-42.86	41 ^a
Service and repair small gasoline engines	45.33	1.33	53.33	-44.00	40
Identify the basic principles of electrical wiring	45.45	1.30	53.25	-44.16	39 ^a
Demonstrate out-of-position welding	51.95	7.79	40.26	-44.16	38 ^a
Select wiring materials and supplies	48.00	1.33	50.67	-46.67	37
Identify types of metal	49.35	2.60	48.05	-46.75	36 ^a
Estimate the materials cost for project construction	49.35	2.60	48.05	-46.75	35 ^a
Select and use wood and metal fasteners	51.32	3.95	44.74	-47.37	34 ^a
Diagnose power system conditions	53.95	6.58	39.47	-47.37	33 ^a
Identify symbols used in agricultural wiring plans	49.35	1.30	49.35	-48.05	32

Note: NR = Negative Ranks; PR = Positive Ranks; TR = Tied Ranks; RDS = Ranked Discrepancy Score;

^a Formula used to rank tied RDS scores

Conclusions, Implications, and Discussion

The combination of the highly technical nature of agricultural mechanics (Albritton & Roberts, 2020) and the reduced credit hours for preservice teachers in the content area (Granberry et al., 2023) has created an evident issue. Preservice teachers have frequently expressed concerns regarding their self-efficacy to teach agricultural mechanics (Burriss et al., 2010; Granberry et al., 2022; Hainline et al., 2018; Tummons et al., 2017). The findings of this study confirm that, based on faculty perceptions, preservice teachers need training in multiple content areas under the agricultural mechanics umbrella. Of the 59

competencies in the instrument, all competencies exhibited negative RDS, indicating a need for training in those areas. Additionally, none of the 59 competencies in this study had an average perception of importance greater than or equal to the average perceived level of preservice teacher preparation. These findings represent a broad need for agricultural mechanics training for preservice and early career SBAE teachers, of which many teacher educators are cognizant.

However, patterns begin to emerge when evaluating the specific needs based on the perceptions of SBAE teacher educators. The most evident deficit was present in the top 25% of ranked competencies. Nine of these 15 competencies were technology-based and represented innovations in *agricultural machinery and equipment, metal fabrication, project planning and materials selection, and renewable energy*.

These findings aligned with Wells et al. (2021b), who found Unmanned Aerial Vehicles and CNC equipment in the top 25% of in-service SBAE teachers' agricultural mechanics professional development needs. However, the current study utilized more technology-based competencies than those presented by Wells et al. (2021b). The number of technology-based competencies ranking at the top of the list of competencies indicated that a greater percentage of faculty perceived these competencies to have greater importance than the level of preparation received by their preservice teachers.

In light of these findings, we question the cause of this discrepancy and its impact on new SBAE teachers as they begin their careers. Precision agriculture and agricultural technology, engineering, and mechanization have been identified as areas of growth that will likely be critical to the agricultural industry in the future (Warren-English et al., 2019). If preservice teachers are perceived as *poorly prepared* in agricultural mechanics technology, they must rely on educational experiences outside of their teacher preparation programs to gain the knowledge and skills necessary to include these technologies in their teaching. Smith et al. (2018) found that nearly half of SBAE teachers preferred to observe others using educational technologies before they were willing to adopt them. If the findings of Smith et al. (2018) were considered in an agricultural mechanics setting, a potentially detrimental outcome could emerge for agricultural mechanics technology in SBAE settings.

The findings related to renewable energy are troubling, considering that non-hydroelectric renewable energy sources were projected to be the fastest-growing forms of U.S. energy generation, and the domestic production and use of biofuels is expected to increase through 2050 (U.S. Energy Information Administration, 2021). Additionally, the Bureau of Labor Statistics (2021) indicated that wind turbine service technicians and solar photovoltaic installers ranked first and third as occupations with the highest projected growth by 2029. According to Hancock et al. (2017), this boom in renewable energy has also carried over to agricultural industries:

Alternative means of electricity generation are growing to meet the energy demands of farming operations and to reduce costs. Several technologies, including alternative fuels, methane digesters, small-scale solar panels, wind power turbine generators, and biomass generation, are sources of renewable power for agricultural buildings. (p. 66)

Consequently, as energy production diversifies, the need for skilled workers in renewable energy systems increases (Bureau of Labor Statistics, 2021). Roberts and Ball's (2009) model for agriculture as a content and a context for teaching emphasized agricultural literacy and relevant skills as dual goals for SBAE. For renewable energy, industry demands and innovations in energy production justify renewable energy to be included in modern agricultural curricula as both a topic by which students should be generally familiar as a potential career. Therefore, SBAE holds a unique position in education at the intersection of knowledge and application relating to natural resources, making for an ideal environment to deliver renewable energy education, particularly in solar energy, wind energy, and biofuels (Acker et al., 2008; Franklin, 2020). This opportunity has been noticed, as the AFNR PSTS (NCAE, 2015) includes standards to develop students' academic and career success in renewable energy, and prominent secondary

agricultural mechanics texts include units on renewable and alternative energies (Hancock et al., 2017; Koel et al., 2013).

The competencies with the smallest training deficits represented the *outdoor power equipment and small gasoline engines, metal fabrication, hand and portable power tools, and electricity* content areas. These competencies hold high average perceptions of importance in preservice teacher preparation and are present in the coursework of over 50% of institutions that require agricultural mechanics courses (Granberry et al., 2023; Trickett et al., 2023). While the presence of these competencies near the bottom of the RDS rankings is promising, it is important to note that they all had negative RDS values, indicating a perception of some need for additional training.

The findings of this study also indicated that SBAE teacher educators were aware of the agricultural mechanics training needs of newly certified teachers from their programs. We recommend that teacher educators use their knowledge of the needs of their students to facilitate professional development in the areas in which they perceive a need for training. A potential outlet for impactful agricultural mechanics-based professional development may stem from industry partnerships with companies with a vested interest in SBAE students' skill development. Wells and Hainline (2021) made similar recommendations to include industry partners in curriculum validation, experiential learning, and teachers' professional development. One example of a successful industry partnership for professional development is the Briggs and Stratton (2021) Field School. The Briggs and Stratton Field School is a professional development opportunity for Career and Technical Education teachers to become trained in an industry-backed experiential learning curriculum in small gasoline engines. If similar professional development partnerships in other areas of agricultural mechanics can be formed, especially involving technology, the outcomes for SBAE teachers and students may be positively impacted. Similarly, the CASE AST and MSA curricula and associated professional developments may be an impactful avenue for increasing the STEM aspects present in agricultural mechanics education. Although Wells et al. (2021b) determined that the CASE MSA curriculum needed continued refinement, their findings and conclusions supported the need for SBAE teacher training in modern technology associated with agricultural mechanics.

Our final recommendation for research was based on the methodology and data analysis techniques we used in this study. We analyzed data by using Narine and Harder's (2021) RDM. Because the RDM is a novel method of analyzing paired-data needs assessments, more research is needed to determine its effectiveness across multiple agricultural and extension education topics. Narine and Harder (2021) reported a statistically significant, very strong, positive correlation ($r = 0.98$) between the Borich (1980) Model and the RDM when using both methods to analyze the same data set. With that finding in mind, the Borich Model is a widely utilized tool for SBAE teacher professional development needs assessments, though it is often challenging to implement. Therefore, further research on the RDM and an evaluation of the Borich Model is needed across a wide range of SBAE topics to determine the situational appropriateness of each research method and if one proves more effective.

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