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Inservice Needs of Selected Arkansas Agriculture Teachers Related to Precision Agriculture

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Abstract

The purpose of this study was to determine selected Arkansas school-based agricultural education (SBAE) teachers' perceptions of the importance, ability to teach, inservice needs, and barriers relative to incorporating precision agriculture (PA) into their programs. A non-probability sample (*n* = 44) of teachers participating in an introductory PA workshop completed the survey. Teachers rated each of the PA competencies as being above average or high importance but rated their ability to teach each competency as being none or below average. When competencies were grouped into seven PA topics, teachers had inservice needs for each topic with mean weighted discrepancy scores (MWDSs) ranging from 8.16 (guidance and autosteering systems) to 11.81 (geographic information systems). Years teaching experience, row-crop experience, and experience with PA had negligible to substantial negative correlations with inservice needs in each PA topic. A majority of teachers rated the lack of equipment (86.3%), curriculum materials (84.1%), personal knowledge (81.9%), and inservice opportunities (63.7%) as being either moderate or serious barriers to incorporating PA into their programs. These results indicated a perceived need for inservice education in PA, provided insight into priority topics, and identified potential barriers to incorporating PA into the curriculum.

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Introduction and Problem Statement

Precision agriculture (PA) is a management approach that applies technology to manage spatial and temporal variation in crop production with the potential to improve economic and environmental sustainability (Association of Equipment Manufacturers, 2023; Oliver et al., 2013). PA technologies include real-time kinematic GPS for on-the-go position monitoring, variable rate technology for application of inputs (seed, fertilizer, and chemicals), unmanned aerial vehicles for digital image acquisition, guidance and autosteering for machine operation, yield monitoring and mapping for collecting georeferenced yield data, soil sensing for measuring and mapping soil properties, and geographic information systems for storing and mapping georeferenced agronomic data (Ess & Morgan, 2017; McFadden et al., 2023; Skouby, 2017).

A 2019 survey of 165 primarily Midwestern US farm supply companies (Erickson & Lowenberg-DeBoer, 2020) found that 92% used real-time kinematic GPS and guidance and autosteering systems, 81% used geographic information systems, 40% used unmanned aerial vehicles, and 27% used soil sensing technology; only 4% reported not using any PA technology. Erickson et al. (2018) found a majority of farm supply employers preferred high school or community college graduates for PA equipment operator (81%) and technician (59%) positions.

Despite these PA career opportunities PA is not commonly taught in school-based agricultural education (SBAE) programs due to a lack of funding, equipment, teacher knowledge, and curriculum materials (Chad, 2022). Therefore, a need existed to determine the specific inservice needs of selected Arkansas SBAE teachers related to PA and to determine their perceptions of barriers to teaching PA. This data could be used to assist PA implementation.

Theoretical and Conceptual Framework

Shulman's (1986, 1987) work related to teacher knowledge formed the theoretical framework for this study. According to Shulman, effective teaching requires content knowledge (CK) and general pedagogical knowledge (GPK), plus a blending of these two types of knowledge into a specialized form of teacher knowledge called pedagogical content knowledge (PCK). According to Shulman (1987), PCK "is that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding" (p. 8). Shulman (1986) stated that PCK involves "the ways of representing and formulating the subject that make it comprehensible to others . . . [through] . . . the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations" (p. 9).

According to Etkina (2010), "deep content knowledge is a necessary condition for the development of PCK" (p. 2). Research in mathematics education (Caparo et al., 2005), science education (Etkina, 2010; Neumann et al., 2019), and agricultural education (Rice & Kitchel, 2015; Wooditch et al., 2018) broadly supports this contention. Grossman et al. (1989) highlighted the importance of CK when they stated, "Good teachers not only know their content but know things about their content that make effective instruction possible'' (p. 24). Because CK is essential to the development of PCK, this study focused primarily on evaluating teacher's CK as a precursor to the development of PCK for teaching PA principles, practices, and application skills.

Purpose

The purpose of the study was to determine the inservice needs of selected Arkansas school-based agriculture education (SBAE) teachers related to Precision Agriculture (PA). Specific objectives were to determine:

1. The perceived importance Arkansas SBAE teachers place on teaching selected PA topics in their programs.
2. Arkansas SBAE teachers' perceived abilities to teach selected PA topics.
3. The in-service needs of Arkansas SBAE teachers related to the PA topics as indicated by mean weighted discrepancy scores (MWDSs).
4. The relationship between Arkansas SBAE teacher and community characteristics, and teacher PA in-service needs.
5. Arkansas SBAE teachers' perceptions of barriers to incorporating PA competencies into the curriculum.

Methods

This study employed a non-probability convenience sample (n = 44) of Arkansas SBAE teachers participating in a two-hour introduction to PA workshop conducted in July 2023 as part of the state agriculture teacher summer conference. Paper surveys were administered immediately prior to the workshop and all teachers provided usable data. Because a non-probability sample was used, these results should not be generalized beyond the respondents; however, according to Johnson and Shoulders (2017), "Studies yielding valid results of interest to the profession from a specific group of respondents, regardless of their generalizability, can add to the body of knowledge and assist researchers as they design and conduct research" (pp. 310-311).

The survey instrument contained three sections. The first section listed 29 specific PA competencies, grouped into seven PA topics (RTK-GPS, 3 items; variable-rate technology, 5 items; unmanned aerial vehicles, 4 items; guidance and autosteering, 4 items; yield monitoring and mapping, 4 items; soil sensing, 4 items; and geographic information systems, 5 items). Each PA topic was described in the instrument prior to each pair of scales. The competencies were identified based on previous research (Ess & Morgan, 2017; McFadden et al., 2023; Skouby, 2017). For each competency, respondents rated (a) the importance of teaching the competency to their students, and (b) their current ability to teach the competency. Importance and ability were both measured on 1 to 5 Likert scales (1 = *no importance/ability*, 2 = *below average importance/ability*, 3 = *average importance/ability*, 4 = *above average importance/ability*, and 5 = *high importance/ability*). The second section listed seven potential barriers to teaching precision agriculture (Chad, 2022) measured on a 1 to 4 Likert-type scale (1 = *not a barrier*, 2 =

minor barrier, 3 = *moderate barrier*, and 4 = *serious barrier*). The third section contained five items related to teacher and community characteristics such as years of teaching experience, experience with row crop farming and precision agriculture, school ZIP code, and teacher perceptions of their county's economic dependance on row crop farming.

The instrument was reviewed by a panel consisting of two university experts in PA and two in social science research who were familiar with the research context and objectives; these experts judged the instrument to possess face and content validity (Gates, et al., 2018). Coefficients of stability, established with 13 preservice agricultural education students who completed the instrument twice at a 14-day interval, ranged from .85 to .98 for PA importance and from .57 to .93 for PA ability. Reliability for potential barriers was .93. Because inservice priorities were identified by PA cluster, not by individual competencies, coefficient alpha reliabilities were estimated *post-hoc* to determine the extent to which teachers' ratings of importance and ability, respectively, were consistent within each PA cluster**.** Coefficient alpha reliability estimates for the summated PA topic importance scales ranged from .86 (unmanned aerial vehicles) to .96 (yield monitoring and mapping); reliability estimates for the summated PA ability scales ranged from .93 (unmanned aerial vehicles) to .98 (multiple scales).

Mean weighted discrepancy scores (MWDS) were calculated for each of the seven PA topics using Equation 1 based on Borich (1980).

$$\text{MWDS} = [(\Sigma \text{I} - \Sigma \text{A}) / \text{N}] \times M_{\text{IT}}. \qquad (1)$$

Where: MWDS = Mean weighted discrepancy score for the PA topic. ΣI = Sum of the importance ratings for all competencies in the PA topic. ΣA = Sum of the ability ratings for all competencies in the PA topic. N = Number of competencies in the PA topic M_{IT} = Mean importance rating for all competencies in the PA topic.

Based on the 1 to 5 scales used to measure both importance and ability, each MWDS could theoretically range from −4.0 to 20.0, with larger positive scores indicating greater inservice needs (Borich, 1980). Because each MWDS was based on summated importance and ability scales for each PA topic, the mean importance scores were considered interval level measurements (Batterton & Hale, 2017; Dillman et al., 2014; Norman, 2010), overcoming the criticisms of MWDS calculated on individual ordinal level items (Narine & Harder, 2021).

Findings

Among the 44 respondents, teaching experience ranged from 0 years (two newly hired teachers) to 42 years (1 teacher), with a median of 12.0 years and an interquartile range of 22.0 years. A majority of respondents (88.6%) reported no experience with row crop farming or with PA technologies (77.3%). Analysis of school ZIP codes indicated that 20 (45.5%) teachers taught at schools located in the two primary row crop areas of Arkansas, the Arkansas River Valley and the Arkansas Alluvial Plain while the remaining teachers (54.5%) taught at schools located in areas primarily characterized by poultry, timber, and livestock production (Williams, 2023).

When asked to indicate the extent to which their county was economically dependent on row crop agriculture, 43.2% indicated "not at all dependent," 27.3% indicated "somewhat dependent," and 29.6% indicated "highly dependent."

The first objective was to determine the importance teachers placed on teaching the PA topics and competencies (see Table 1). Using the vague descriptors suggested by Lindner and Lindner (2024) for summated 5-point Likert scales, teachers rated the importance of teaching each PA topic as being of "above average" importance. Based on the mean topic importance ratings, the unmanned aerial vehicle and geographic information systems were the most important topics while the yield monitoring and mapping and guidance and autosteering topics were the least important. Only one individual competency (configure a yield monitoring system) was rated as being of no or below average importance by 10% or more of the teachers; conversely, each of the 29 competencies was rated as being of above average or high importance by between 70.5% and 93.3% of the teachers.

Table 1

Arkansas SBAE Teachers' Perceptions of the Importance of PA Topics and Competencies

	Importance				
PA Topic Competency	None or below average[a] (%)	Average (%)	Above average or high[b] (%)	*M*[c]	*SD*
Unmanned aerial vehicles (UAVs)				4.40	0.59
Use computer program to analyze digital UAV images	0.0	6.8	93.2		
Develop a "mission plan" to fly UAV	0.0	9.1	90.9		
Manually fly a UAV	2.3	6.8	90.9		
Select correct camera for specific UAV application	2.3	9.1	88.6		
Geographic information systems (GIS)				4.39	0.62
Create a field map	2.3	4.6	93.2		
Determine sources of geographic data	0.0	9.1	90.9		
Edit a field map	2.3	6.8	90.9		
Describe coordinate system used in GIS	2.3	6.8	90.9		
Import data into a GIS program	0.0	15.9	84.1		
Soil sensing (SS)				4.23	0.65
Select the correct sensor for a specific task	2.3	9.1	88.6		
Use a computer program to analyze soil sensor data	0.0	13.6	86.4		
Determine when to use proximal and remote sensing	2.3	13.6	84.1		
Determine when to use grid vs. zone sampling	2.3	15.9	81.8		

PA Topic Competency	Importance None or below average[a] (%)	 Average (%)	 Above average or high[b] (%)	*M*[c]	*SD*
Variable rate technology (VRT)				4.20	0.0.74
Identify the primary components of VRT system	2.3	9.1	88.6		
Operate VRT equipment in the field	2.3	9.1	88.6		
Identify common sensors used in VRT	2.3	11.4	86.4		
Configure a variable rate controller	2.3	13.6	84.1		
Develop a prescription application map	4.6	15.9	79.5		
Realtime kinematic GPS (RTK-GPS)				4.17	0.66
Pair tractor or implement receiver (rover) with RTK base station	0.0	15.9	84.1		
Explain basic operating principles of RTK-GPS	0.0	18.2	81.8		
Identify sources of position error in RTK-GPS	0.0	22.7	77.3		
Yield monitoring and mapping (YMM)				4.07	0.0.87
Identify common sensors used in YMM systems	6.8	13.6	79.6		
Configure a yield monitoring system	11.4	9.1	79.6		
Calibrate a grain moisture sensor	6.8	15.9	77.3		
Identify primary components of a YMM system	9.1	15.9	75.0		
Guidance and autosteering systems (GAS)				3.98	0.88
Operate a tractor in the field with lightbar	4.6	15.9	79.5		
Operate a tractor in the field with autosteering	6.8	15.9	77.3		
Set an AB line and swath width for autosteering	6.8	15.9	77.3		
Set an AB line and swath width for lightbar guidance	9.1	20.4	70.5		

Note. [a]Combined no and below average importance responses. [b]Combined above average and high importance responses. [c] Based on 5-point scale where 1 = *no ability*, 2 = *below average ability*, 3 = *average ability*, 4 = *above average ability* and 5 = *high ability*.

The second objective was to determine teachers' perceived ability to teach the PA topics and competencies (see Table 2). Using the vague quantifiers suggested by Lindner and Lindner (2024), teachers perceived their ability to teach each PA topic as below average. Teachers rated their ability to teach the soil sensing, unmanned aerial vehicle, and guidance and autosteering topics highest, and the variable rate technology, real-time kinematic GPS, geographic information systems, and yield monitoring and mapping topics lowest. Between 61.4% and 84.1% of teachers rated themselves as having no or below average ability to teach each of the 29 PA competencies. Conversely, between 2.3% and 20.4% rated themselves as having above average or high ability to teach each of the 29 PA competencies.

Table 2

Arkansas SBAE Teachers' Perceptions of Their Ability to Teach PA Topics and Competencies

	Ability				
PA Topic Competency	None or below average[a] (%)	Average (%)	Above average or high[b] (%)	*M*[c]	*SD*
Soil sensing (SS)				2.29	0.69
Select the correct sensor for a specific task	79.6	13.6	6.8		
Determine when to use grid vs. zone sampling	84.1	9.1	6.8		
Determine when to use proximal and remote sensing	84.1	11.4	4.6		
Use a computer program to analyze soil sensor data	77.3	18.2	4.5		
Unmanned aerial vehicles (UAVs)				1.99	1.08
Use computer program to analyze digital UAV images	79.6	9.1	11.4		
Develop a "mission plan" to fly UAV	68.2	15.9	15.9		
Manually fly a UAV	61.4	18.2	20.4		
Select correct camera for specific UAV application	75.0	11.4	13.6		
Guidance and autosteering systems (GAS)				1.93	1.21
Operate a tractor in the field with lightbar	68.2	15.9	15.9		
Operate a tractor in the field with autosteering	70.5	15.9	13.6		
Set an AB line and swath width for autosteering	72.7	18.2	9.1		
Set an AB line and swath width for lightbar	72.7	18.2	9.1		
Variable rate technology (VRT)				1.76	0.88
Identify the primary components of VRT system	77.3	18.2	4.5		
Operate VRT equipment in the field	77.3	13.6	9.1		
Identify common sensors used in VRT	79.6	15.9	4.5		
Configure a variable rate controller	79.6	18.2	2.3		
Develop a prescription application map	77.3	20.4	2.3		

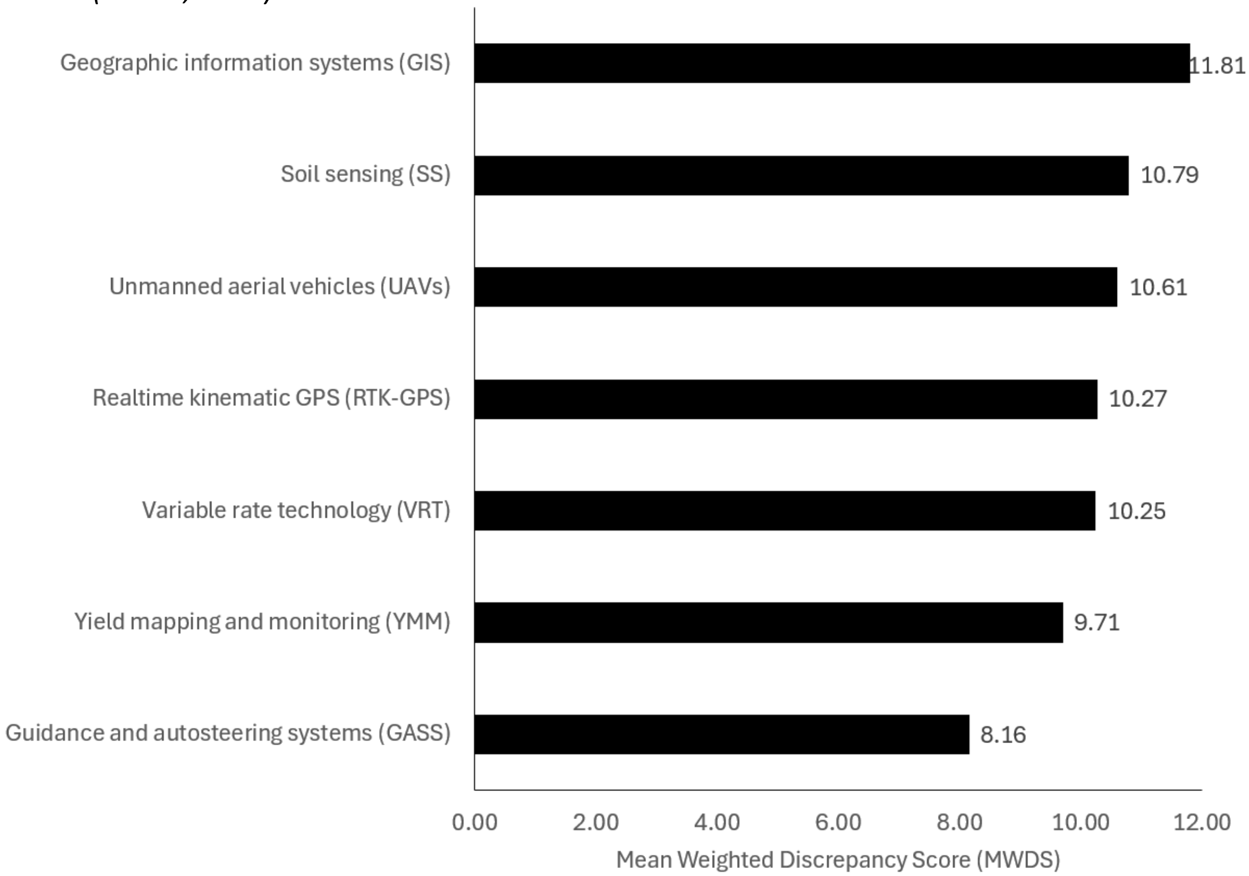
PA Topic Competency	Ability: None or below average[a] (%)	Ability: Average (%)	Ability: Above average or high[b] (%)	*M*[c]	*SD*
Realtime kinematic GPS (RTK-GPS)				1.71	0.81
Pair tractor or implement receiver (rover) with RTK base station	84.1	13.6	2.3		
Explain basic operating principles of RTK-GPS	68.2	29.5	2.3		
Identify sources of position error in RTK-GPS	84.1	13.6	2.3		
Geographic information systems (GIS)				1.70	0.94
Create a field map	72.7	20.4	6.8		
Determine sources of geographic data	75.0	18.2	6.8		
Edit a field map	75.0	18.2	6.8		
Describe coordinate system used in GIS	79.6	15.9	4.5		
Import data into a GIS program	79.6	13.6	6.8		
Yield monitoring and mapping (YMM)				1.68	0.95
Identify common sensors used in YMM systems	79.6	15.9	4.5		
Configure a yield monitoring system	79.6	15.9	4.5		
Calibrate a grain moisture sensor	79.6	13.6	6.8		
Identify primary components of a YMM system	77.3	13.6	9.1		

Note. [a]Combined no and below average ability responses. [b]Combined above average and high ability responses. [c]Based on 5-point scale where 1 = no ability, 2 = below average ability, 3 = average ability, 4 = above average ability and 5 = high ability.

The third objective was to determine the PA inservice needs of Arkansas SBAE teachers. When inservice needs were prioritized using MWDSs (see Figure 1), the highest need was in the geographic information systems topic (MWDS = 11.81) and the lowest inservice need was in the guidance and autosteering topic MWDS = 8.16). However, the relative magnitude of the MWDSs indicated inservice needs in each of the seven PA topics. By comparison, the lowest MWDS in this study was higher than the largest score (MWDS = 5.59) reported by Wells and Hainline (2021) in a national study (using the same 1 to 5 scaling) of teacher inservice needs related to more traditional agricultural mechanics competencies.

Figure 1

Arkansas SBAE Teachers' PA Inservice Needs as Prioritized by Mean Weighted Discrepancy Scores (Borich, 1980)



The fourth objective was to determine the relationship between selected teacher characteristics and perceived PA inservice needs. The demographic variables years of teaching experience, experience with row crop farming, and PA experience all had negative correlations with PA inservice needs (as indicated by MWDS) for each PA technology (see Table 3). More experienced teachers, those with row crop experience, and those with precision agriculture experience indicated somewhat less need for inservice in each of the PA topics. The magnitude of these correlations ranged from negligible to moderate (Davis, 1971), with the largest correlation (r = -.36 between PA experience and the MWDS for unmanned aerial vehicles) explaining only 13.0% of the variance in inservice needs.

Table 3

Relationship Between Selected Arkansas SBAE Teacher Characteristics and Inservice Needs by PA Topic

PA Topic	Years taught	Row crop experience[a]	PA experience[a]
Geographic information systems (GIS)	-.19	-.13	-.16
Unmanned aerial vehicles (UAVs)	-.19	-.26	-.36
Realtime kinematic GPS (RTK-GPS)	-.11	-.24	-.23
Variable rate technology (VRT)	-.23	-.19	-.02
Yield mapping and monitoring (YMM)	-.17	-.19	-.01
Soil sensing (SS)	-.25	-.11	-.17
Guidance and autosteering systems (GASS)	-.10	-.21	-.33

Note. [a]Coded as No = 0 and Yes = 1 and analyzed using point-biserial correlations.

The final objective was to describe teachers' perceptions of the barriers to incorporating PA into their programs (see Table 4). Lack of equipment for teaching PA was perceived as a serious barrier for almost three-fourths (72.7%) of the teachers and as a moderate barrier by an additional 13.6% of teachers. A majority of teachers also indicated that lack of curriculum materials (84.1%), level of personal knowledge (81.9%), and lack of inservice opportunities (63.7%) were either moderate or serious barriers (combined categories) to incorporating PA into their programs. Conversely, only a minority of teachers perceived lack of administrator support (34.1%), lack of fit with state curriculum standards (27.3%), or lack of student interest (22.8%) as being moderate or serious barriers to incorporating PA into their programs.

Table 4

Arkansas SBAE Teachers' Perceived Barriers to Incorporating PA into SBAE Programs

	Not a barrier		Minor barrier		Moderate barrier		Serious barrier	
Potential barrier	*f*	%	*f*	%	*f*	%	*f*	%
Lack of equipment	1	2.7	5	11.4	6	13.6	32	72.7
Lack of curriculum materials	0	0.0	7	15.9	18	40.9	19	43.2
Level of personal knowledge	1	2.7	7	15.9	20	45.5	16	36.4
Lack of inservice opportunities	1	2.3	15	34.1	20	45.5	8	18.2
Lack of administrator support	12	27.3	17	38.6	10	22.7	5	11.4
Lack of student interest	16	36.4	18	40.9	8	18.2	2	4.6
PA does not fit state standards	21	47.7	11	25.0	10	22.7	2	4.6

Conclusions, Discussion, and Recommendations

This study used a non-probability sample of Arkansas SBAE teachers, so caution should be used in generalizing the findings beyond the respondents. However, because the study participants self-selected to attend an inservice workshop on PA technologies they may be the most likely to teach PA in their agriculture programs. Additionally, the findings and recommendations may have practical implications for similar groups of teachers.

Few Arkansas SBAE teachers had experience in row crop production or with PA. The MWDS for each PA topic indicated a high perceived need for inservice education with MWDSs higher than those reported by Wells and Hainline (2022). Therefore, teacher inservice workshops should be offered with immediate priority placed on geographic information systems, soil sensing, unmanned aerial vehicles, real-time kinematic GPS and variable rate technology. These workshops should focus on the specific PA competencies included in the survey instrument. Years of teaching experience, row crop experience, and PA experience were all negatively correlated to PA inservice needs but did not explain large amounts of variance in inservice needs. Therefore, little need exists to target PA workshops to specific subgroups of teachers.

In addition to a lack of personal PA knowledge, teachers perceived that a lack of curriculum materials and a lack of equipment posed moderate to serious barriers to teaching PA. Because PA is not being taught in Arkansas SBAE programs, teachers are likely unaware of a variety of free and low-cost curriculum materials currently available from a number of sources. State agricultural education leaders should evaluate and curate a list of the best materials, categorized by PA topic and containing appropriate hyperlinks or contact information, and share this list with interested teachers.

The cost of hands-on laboratory materials is a more difficult barrier to overcome. While PA educators have described relatively inexpensive models for teaching yield monitoring and mapping (Massey et al., 2020), variable rate application (Dickinson, et al., 2007; Massey & Kirk, 2013), and geographic information systems (Nawaz & Sattar, 2016), some equipment is beyond typical SBAE program budgets. Agricultural educators should explore opportunities for equipment grants, cooperative ownership and sharing of teaching equipment, and industry and dealer partnerships to support hands-on PA instruction.

Incorporating PA into the SBAE curriculum will be challenging. But, given the importance of PA and the employment and further education opportunities associated with PA, efforts must be made to overcome these barriers and incorporate PA into the SBAE curriculum.

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