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Examining Differences in Teachers' Agricultural Mechanics Professional Development Needs: A National Study

Mark S. Hainline [1]
Trent Wells [2]

Abstract

Agriculture teachers need knowledge and skills in a range of agricultural mechanics topics, such as metal fabrication and power mechanics. Teacher professional development (PD) is one method for improving teacher competence. Both Sorensen et al. (2014) and Yopp et al. (2020) reported differences in teachers' PD needs based on years of teaching experience. Could their findings be consistent on a national level? Moreover, do other teacher demographic factors such as teacher certification route and career phase yield differences in teachers' agricultural mechanics PD needs? Using human capital theory as our guiding framework, the purpose of our study was to examine potential differences in teachers' agricultural mechanics PD needs based on selected teacher demographic factors. We employed Borich's (1980) needs assessment model to structure our study. Further, we used a valid and reliable 72-item instrument and followed Dillman et al.'s (2014) recommendations to collect data from a random sample of teachers from across the United States. One hundred teachers responded to our instrument, yielding a response rate of 27.5%. We found that: (1) there were no statistically significant differences in teachers' agricultural mechanics PD needs based on teacher certification route and (2) there were statistically significant differences in teachers' agricultural mechanics PD needs based on career phase. We recommend that Agricultural Education stakeholders facilitate career phase-differentiated PD opportunities for teachers. Doing so will help to positively impact the teacher competence development process for those who most need it.

Introduction and Review of Literature

Well-prepared, competent, and effective teachers are a requisite component of high-quality learning environments (Darling-Hammond et al., 2017; Whittington, 2005). Competent teachers are better able to address complex and challenging teaching and learning needs within their respective classrooms and schools (Darling-Hammond et al., 2017). The development of competent teachers is a substantial, long-term process requiring diverse inputs, such as field-based experiences and subject matter-specific coursework to provide experience, knowledge, and skills relevant to classroom teaching (Whittington, 2005).

Regarding subject matter knowledge, teachers need an adequate working knowledge of the content they teach to be successful (Ward, 2009). This conclusion is not lost within the context of Agricultural Education. Prior research (Eck et al., 2019; Granberry et al., 2023; Roberts & Dyer,

[1] Mark S. Hainline is an Assistant Professor of Agricultural Education in the School of Agricultural Sciences at Sam Houston State University, 440L Fred Pirkle Engineering Technology Center, Huntsville, TX 77341, msh004@shsu.edu

[2] Trent Wells is an Assistant Professor of Agricultural Education in the Hutson School of Agriculture at Murray State University, 206 South Oakley Applied Science, Murray, KY 42071, kwells23@murraystate.edu

2004) has indicated that agriculture teachers need adequate agricultural subject matter knowledge to effectively provide instruction within their programs. Teachers' agricultural subject matter knowledge and experiences can be leveraged to deliver relevant, rigorous, and robust instruction that benefits students and the agricultural industry at large (Roberts & Ball, 2009). The agricultural subject matter knowledge needs of agriculture teachers are diverse and include several technical agriculture areas, including agricultural mechanics (Albritton & Roberts, 2020).

As agricultural subject matter, agricultural mechanics is a popular choice with students enrolled in Agricultural Education coursework (Valdez & Johnson, 2020) and is consequently taught in programs across the United States (Burris et al., 2005; Granberry et al., 2023). Agriculture teachers need to be knowledgeable and skilled in a battery of agricultural mechanics topics, such as power mechanics, metal fabrication, and structures construction (Granberry et al., 2023; Hainline & Wells, 2019; Wells & Hainline, 2021; Wells et al., 2021). The high availability and frequent use of agricultural mechanics laboratories (Shoulders & Myers, 2012) help reinforce this need. As agricultural mechanics instruction is primarily laboratory-based, adequate teacher competence is mandatory to help avoid safety and laboratory management issues that can create teacher liability issues and concerns (Chumbley et al., 2018; Hainline et al., 2019; Saucier et al., 2014). Taking proactive measures, such as ensuring teachers are competent in their subject matter, can help mitigate potential teacher liability issues associated with teaching and learning (Love, 2013). Thus, it is imperative agriculture teachers be competent and adequately prepared to teach agricultural mechanics.

Both pre-service (Granberry et al., 2022; Tummons et al., 2017) and in-service (Burris et al., 2010) agriculture teachers often express that they feel under-prepared to teach agricultural mechanics. These beliefs often include lack of confidence to teach technical skills such as welding (Blackburn et al., 2015) and concerns about competence to teach agricultural mechanics more broadly (Tummons et al., 2017). These findings have implications for agricultural mechanics instruction in Agricultural Education programs. Zirkle and Barnes (2011) indicated teachers may elect to forego teaching in laboratory settings altogether if perceived risks of teaching the subject matter (e.g., self-perceived lack of competence, teacher liability concerns, etc.) outweigh perceived benefits. Teachers evading agricultural mechanics instruction could have negative impacts on the nature and scope of Agricultural Education programs, subsequently affecting learning opportunities for students and involvement in local community activities. Examining how to positively impact teacher competence in agricultural mechanics is an endeavor worth pursuing.

Teacher professional development (PD) is one method for improving teacher competence (Ward, 2009). Darling-Hammond et al. (2017) deemed effective PD "as structured professional learning that results in changes in teacher practices and improvements in student learning outcomes" (p. v). Yoon et al. (2007) noted that "teachers who receive substantial professional development… can boost their students' achievement" (p. iii), thereby positively impacting the learning environment. Nadelson et al. (2012) indicated that as teachers learn more about their subject matter, they express a greater degree of comfort with teaching it. Nadelson et al. (2012) also found PD can yield substantial increases in technical subject matter knowledge.

Teacher PD in the context of Agricultural Education has been studied extensively. Prior literature (Blanton, 1972; Grieman, 2010) has consistently indicated continuing education is important for teachers' professional growth. More recently, several scholars (Clemons et al., 2018; Smalley et al., 2019; Sorensen et al., 2014) studied agriculture teachers' PD needs, noting that teachers have PD needs across a wide range of technical agriculture subject matter, including agricultural mechanics. As agriculture teachers report high participation in PD activities and place a greater meaning on PD directly related to their subject matter (Easterly & Myers, 2019), understanding potential and specific differences in teachers' PD needs is important. Doing so will help the profession better understand how to address teacher competence development, particularly in agricultural mechanics.

In the context of Agricultural Education, DiBenedetto et al. (2018), who synthesized three decades of agriculture teachers' needs assessments research, posited "competency levels and priority areas of needs are diverse and somewhat inconsistent depending on the level of teaching experience (pre-service, novice, or experienced / senior teachers) and type of teacher certification (traditionally- or alternatively-certified teachers)" (p. 66). Congruent with DiBenedetto et al.'s (2018) findings, other scholars have also expressed the need to provide differentiated PD for alternatively-certified (AC) teachers (Roberts & Dyer, 2004; Ruhland & Bremer, 2002; Zientek, 2006). Ruhland and Bremer (2002) noted AC teachers are more likely to feel better prepared when it comes to the content but feel less prepared with pedagogical concepts in comparison to traditionally-certified (TC) teachers.

Bowling and Ball (2018) insisted PD for AC agriculture teachers should focus on classroom / laboratory management techniques and techniques associated with advising student organizations (e.g., the National FFA Organization). While many scholars have found that AC agriculture teachers have greater PD needs when compared to TC teachers, the findings from other studies have presented mixed results (Roberts & Dyer, 2004; Stair et al., 2019). Stair et al. (2019) concluded there were negligible differences between the PD needs of Louisiana agriculture teachers of various certification routes. Roberts and Dyer (2004) noted TC agriculture teachers in their study had greater self-perceived in-service needs than AC agriculture teachers in "FFA and SAE Supervision, Instruction and Curriculum, Technical Agriculture, Program Management and Planning, and Teacher Professional Development" (p. 67).

Aside from the certification route, teacher career phase has also been identified as an important factor that impacts PD needs. Eros (2011) indicated as teachers progress through different stages of their career cycle, teachers' PD needs are likely to change. Prior research in agricultural teacher education has specified the PD needs of early-career (EC) agriculture teachers are heightened in areas such as facility management, classroom / laboratory management, training Career Development Event (CDE) teams, and managing a program advisory board (Boone & Boone, 2007; Joerger, 2002; Myers et al., 2005; Sorensen et al., 2014). Findings from Sorensen et al. (2014) indicated "teaching agricultural mechanics" (p. 149) was the topic with the largest PD difference between induction and non-induction phase teachers. Additionally, McKim et al. (2017) found intra-curricular facilitation competence to be statistically significantly greater for late-career (LC) teachers when compared to EC teachers.

The impact of teacher certification route and career phase on teachers' PD needs expressed in prior literature warrants further investigation of these factors on agriculture teachers' PD needs in the context of teaching agricultural mechanics. While Sorensen et al. (2014) identified teaching agricultural mechanics as an area with great PD differences between teachers of various career phases, our study delved further into this context by providing a granular lens for determining if PD needs differ in various subject matter areas (e.g., structures, safety, metal fabrication, electrical systems, power mechanics, etc.) within the broader scope of agricultural mechanics. Moreover, both Sorensen et al. (2014) and Yopp et al. (2020) reported differences in PD needs based on years of teaching experience. This indicates that teachers undergo a metamorphosis in their agricultural mechanics PD needs over time. Could Sorensen et al.'s (2014) and Yopp et al.'s (2020) state-specific findings be consistent on a national level? Moreover, do teacher demographic factors such as teacher certification route and teacher career phase result in differences in agriculture teachers' agricultural mechanics PD needs? These questions deserve further inquiry.

Theoretical Framework

We used human capital theory (HCT) to undergird our study. HCT suggests training and education will bolster the productivity and earnings of individuals, thus contributing to their economic productivity and adding value to the broader economy (Garibaldi, 2006; Tan, 2014). Becker (1993) noted that "[e]ducation and training are the most important investments in human capital" (p. 17) and in the context of education human capital serves as the largest single investment for public schools (Myung et al., 2013). PD serves as a means to strengthen the professional practice of teachers to equip them with the tools to raise the achievement of students (Bowgren & Sever, 2009; Darling-Hammond et al., 2017). PD is also intended to enhance value to teachers' contributions to the educational system (Darling-Hammond et al., 2017) and can thus be viewed as an investment in human capital. However, Gabriel (2010) argued effective PD should be differentiated to accommodate the interest, needs, commitment, and awareness of each individual teacher. The notion of a one-size-fits-all approach to teacher PD has been deemed as dangerously ineffective in terms of boosting the engagement and capacity of teachers' professional growth (Bowgren & Sever, 2009; Darling-Hammond & Richardson, 2009; Gabriel, 2010; Ruhland & Bremer, 2002).

In alignment with the larger study of which our current study is a part of, HCT served to frame the need for examining teachers' agricultural mechanics PD needs. Prior literature (Gabriel, 2010) indicated that PD should, whenever possible, account for teachers' individual needs for professional growth. Further, Thoron et al. (2016) indicated that there exists the need for appropriate, effective PD for agriculture teachers. Well-prepared, competent agriculture teachers are fundamental to the success of Agricultural Education programming, which impacts the agricultural industry more broadly (Albritton & Roberts, 2020; Wells et al., 2021). The agricultural industry relies on the availability of appropriate human capital development for its long-term stability and progress (Stripling & Ricketts, 2016).

Purpose, Objectives, and Null Hypotheses

As part of a larger, national-level study focused on ascertaining the agricultural mechanics PD needs of agriculture teachers, the purpose of our study was to examine potential differences in teachers' agricultural mechanics PD needs based on teacher career phase and teacher certification route. We used two research objectives to guide our study:

1) Describe teachers' agricultural mechanics PD needs.

2) Examine the impact of teacher career phase and teacher certification route on teachers' agricultural mechanics PD needs.

We further used three null hypotheses to guide our study's statistical analysis:

H_o1: In the population, there is no statistically significant difference in teachers' agricultural mechanics PD needs based on the interaction of teacher career phase and teacher certification route.

H_o2: In the population, there is no statistically significant difference in teachers' agricultural mechanics PD needs based on teacher certification route.

H_o3: In the population, there is no statistically significant difference in teachers' agricultural mechanics PD needs based on teacher career phase.

Methods

We used Borich's (1980) needs assessment model to structure our study. Other scholars in Agricultural Education (e.g., Clemons et al., 2018; Hainline et al., 2021) have used Borich's (1980) needs assessment model to study teachers' PD needs.

Instrumentation

We used a 72-item instrument to conduct our study. We included a mixture of seven multiple-choice and open-ended items to examine the demographic characteristics of the respondents. Sixty-five items were related to an assortment of agricultural mechanics topics (e.g., *Use of electrical systems tools [ex. digital multi-meter, wire strippers, etc.]*, *Procedures for structural welding*, etc.). The list of agricultural mechanics knowledge and skills needed by agriculture teachers was predicated by Hainline and Wells (2019) to help establish the needs assessment items used in our study. For each needs assessment item, we prompted respondents to specify the importance (1 = Not important [NI], 2 = Of little importance [LI], 3 = Somewhat important [SI], 4 = Important [I], 5 = Very important [VI]) to teach each agricultural mechanics topic within Agricultural Education programs and to then indicate their perceived competence (1 = Not competent [NC], 2 = Little competence [LC], 3 = Somewhat competent [SC], 4 = Competent [C], 5 = Very competent [VC]) to teach each agricultural mechanics topic.

Validity and Reliability

We assessed the validity of our instrument by consulting a panel of seven agricultural teacher educators on the faculty at seven academic institutions across the United States. We deliberately selected each member of the panel to bring diverse, unique experiences and perspectives associated with agricultural mechanics. Panel member one was a professor at a land-grant institution and had prior experience researching agricultural mechanics pertaining to teacher preparation. Panel member two was an assistant professor at a land-grant university and taught agricultural mechanics coursework. Panel member three was an associate professor at a land-grant university and taught both a laboratory-focused instructional methods course and an agricultural mechanics course.

Panel member four was a professor at a land-grant university and had previously taught high school-level agricultural mechanics courses and has chaired committees for graduate students whose research focused around agricultural mechanics-related topics. Panel member five was a professor at a land-grant university. They had taught agricultural mechanics courses at their institution and had conducted research associated with agricultural mechanics in Agricultural Education settings. Panel member six was formerly an assistant professor at a regional university. They taught agricultural mechanics courses at the high school and university levels and had published research related to agricultural mechanics knowledge and skill needs of agriculture teachers. Panel member seven was an associate professor at a land-grant university. This panel member previously taught agricultural mechanics courses at both the high school and university levels and also taught a laboratory-based methods class for pre-service teachers.

We sent an e-mail out to each panel member. Our e-mail contained a copy of the initial version of our instrument and a panel of experts' response form. The panel of experts' response form included detailed instructions about the instrument. We asked the seven panel members assess our instrument for content validity and face validity. We asked the panel members to use the panel of experts form to provide detailed feedback about our instrument and offer suggestions for instrument improvement. We also requested that they send the form and an edited instrument back to us via e-mail. The responses from the panel members noted our instrument would be suitable for our study if their recommendations were undertaken. We subsequently adjusted the instrument based on their feedback (e.g., discarded unnecessary items, combined similar items together, reworded items as suggested), which resulted in the final 72-item instrument used in our study. Our instrument was thus face valid, content valid, and ready to advance to the pilot study stage.

Pilot Study

We assessed the reliability of the *Competence* and *Importance* scales used within the 65-item needs assessment portion of our instrument by way of a pilot study. We conducted our pilot study during the Fall 2019 semester as a census study with all 287 agriculture teachers who taught in Iowa during the 2019-2020 academic year. Based on the recommendations offered by Dillman et al. (2014), we used multiple contacts and incentives (i.e., five \$20.00 gift cards drawn at random) to solicit and encourage participants for our pilot study. Our data collection process for the pilot study involved a total of five iterations of contact: (1) a pre-notice e-mail, (2) an initial invitation to participate, (3) a first reminder, (4) a second reminder, and (5) a third and final reminder. Two of the pilot study email addresses bounced, dropping the total number of potential respondents to 285.

Seventy Iowa agriculture teachers responded to our pilot study instrument (response rate = 24.6%). We calculated Cronbach's alpha coefficients to assess the reliability of the *Competence* and *Importance* scales used within the 65-item needs assessment portion of our instrument. A post-hoc reliability assessment produced Cronbach's alpha coefficients for the *Competence* ($\alpha = .98$) and *Importance* ($\alpha = .97$) scales, which were considered to be acceptable levels of reliability based on the interpretations posited by George and Mallery (2003). At the conclusion of our pilot study, we deemed the scales used in our instrument reliable and we conducted our formal study during the Spring 2020 semester.

Sample

The target population for our formal study encompassed of all agriculture teachers in the United States in the 2019-2020 academic year. Nina Crutchfield, the former South Central Local Program Success Specialist at the National FFA Organization, specified that there were 13,471 agriculture teachers across the nation during the 2019-2020 academic year (personal communication, March 24, 2020). Provided by the National FFA Organization at our request, we used a probabilistic sample of 374 agriculture teachers from across the United States. We calculated the sample size based on Dillman et al.'s (2014) probability sampling calculator (acceptable amount of sampling error = ±5% of the true population; Z statistic associated with confidence level = 1.96, 95% level), which follows Krejcie and Morgan's (1970) formula.

Data Collection

During our formal study, we used Qualtrics to send five e-mail contacts to agriculture teachers. E-mails to 10 teachers bounced (failure rate = .03%), reducing the total number of potential respondents to 364. Using financial incentives with survey research tends to increase response rates (Dillman et al., 2014; Doss et al., 2022). Thus, we elected to use an incentive (i.e., 10 \$20.00 gift cards drawn at random) within our study. Per the recommendations of Dillman et al. (2014), we also used multiple e-mail contacts to help elicit responses. The five e-mail contacts included: (1) a pre-notice about the study, (2) an initial invitation to participate in the study sent, (3) the first reminder, (4) the second reminder, and (5), the third and final reminder.

One hundred agriculture teachers responded to our instrument in the formal study, yielding a response rate of 27.5%. Recent national studies (Sherman & Sorensen, 2020; Sorensen et al., 2017) have had similar response rates (26.8% and 30.08%, respectively). We set a response completion threshold of 75% *a priori*. We excluded six respondents who completed less than 75% of their instrument from our data analysis procedures. After the conclusion of the formal study, we elected to reassess the reliability of the *Competence* and *Importance* scales within the 65-item needs assessment portion of our instrument and we used Cronbach's alpha coefficients to do so. A post-hoc reliability assessment yielded Cronbach's alpha coefficients for the *Competence* ($\alpha = .98$) and *Importance* ($\alpha = .97$) scales, which we once again deemed as having acceptable levels of reliability in accordance with the interpretations provided by George and Mallery (2003).

Data Analysis

We used the IBM® Statistical Package for the Social Sciences (SPSS©) software, Version 27 to analyze our data. To address nonresponse error, we compared early respondents to late respondents in accordance with Lindner et al.'s (2001) recommendations. We considered teachers who responded before we sent the first reminder email ($n = 48$) to be early respondents while we considered teachers who responded after we send the first reminder e-mail ($n = 46$) to be late respondents. We used an independent samples *t*-test to compare responses on all *Competence* scale items. We did not identify any statistically significant differences ($t(92) = -1.43$, $p = .19$) between the groups.

We analyzed the data associated with objective one by calculating descriptive statistics (i.e., frequencies, percentages, measures of central tendency, and measures of dispersion) to describe the educational and professional experiences of the agriculture teachers in this study. To address objective two, we calculated average discrepancy scores for each group of teachers (i.e., EC, mid-career [MC], LC / traditional and non-traditional certification) for each of the 65 needs assessment items. Once we calculated the discrepancy scores for each individual for each item, we averaged the discrepancy scores to calculate the average discrepancy score (ADS) for each item. Aside from the analysis of discrepancy scores, we also calculated the mean and standard deviation for each item and for each group of agriculture teachers.

To address objective three, we conducted a factorial ANOVA to examine the effects of teacher career phase (i.e., EC, MC, and LC) and certification route (i.e., traditional and non-traditional) on teachers' agricultural mechanics PD needs. We operationalized the dependent variable, agricultural mechanics PD needs, by calculating mean discrepancy scores (MDS) for each respondent. To calculate the MDS, we calculated each respondent's discrepancy scores (DS) for each item by subtracting their perceived competence to teach rating (1 = *Not competent*, 2 = *Little competence*, 3 = *Somewhat competent*, 4 = *Competent*, 5 = *Very competent*) from their perceived importance to teach rating (1 = *Not important*, 2 = *Of little importance*, 3 = *Somewhat important*, 4 = *Important*, 5 = *Very important*). We then averaged the DS for all items for each individual to compute their MDS.

We used a residual analysis to test the assumptions of the factorial ANOVA. We used Shapiro-Wilk's test to assess normality, Levene's test to assess the homogeneity of variances, and boxplots and studentized residuals to identify potential outliers. We calculated Partial eta squared (η_p^2) effect sizes to determine the practical significance of the findings. We used Cohen's (1988) effect size classifications to interpret the results (small effect size = 0.0099; medium effect size = 0.0826; and a large effect size is 0.20).

Results

The typical respondent had taught agriculture for an average of 10.51 (*SD* = 9.85) academic years and obtained their agricultural teacher certification via an undergraduate-level teacher preparation program (*f* = 56; 59.57%). We used Solomonson and Retallick's (2018) *Professional Agriculture Teacher Life Cycle Stages* model to designate teachers' career phases. We classified 38 (40.43%) respondents who reported between one and five years of teaching experience as EC teachers, 33 (35.11%) respondents who reported between six and 15 years of teaching experience as MC teachers, and 23 (24.47%) respondents who reported 16 or more years of teaching experience as LC teachers (see Table 1).

Table 1

Teacher Demographics

Item	*f*	%	*M*	*SD*
Teacher Career Phase				
Early-career (EC; 1-5 years of teaching experience)	38	40.43	1.262	0.910
Mid-career (MC; 6-15 years of teaching experience)	33	35.11	0.694	0.835
Late-career (LC; 16+ years of teaching experience)	23	24.47	0.340	0.815
Teacher Certification Route				
Traditional certification	56	59.57	0.667	0.859
Non-traditional certification	38	40.43	1.087	0.990

Note. M = Mean; *SD* = Standard deviation.

The EC teachers had higher ADS, which signified higher PD needs for 63 out of the 65 items on the instrument. The only items which EC teachers needs were not the highest were *Use of handheld power tools (ex. cordless drill, jig saw, etc.)* whereas they had the same ADS as MC teachers (ADS = 0.45), and *Use of computer numerical control (CNC) systems*, with which the MC teachers (ADS = 1.41) indicated a greater need for PD. The items which EC teachers indicated the highest average level of PD needs were *Principles of metallurgy (ex. identifying metals, proper use of metals, etc.)* (ADS = 1.92) and *Procedures for structural welding* (ADS = 1.92). MC teachers highest-indicated PD needs were associated with *Use of computer numerical control (CNC) systems* (ADS = 1.41) and *Procedures for GTAW (TIG welding)* (ADS = 1.19). *Procedures for using unmanned aerial vehicles in land surveying* (ADS = 1.23) and *American Welding Society (AWS) standards for welding procedures* (ADS = 1.10) were the highest-indicated PD needs for LC teachers.

The LC teachers had the lowest ADS, which represented the lowest levels of PD needs, on 62 items on the instrument. *American Welding Society (AWS) standards for welding procedures* (MC: ADS = 1.03; LC: ADS = 1.10), *Procedures for using unmanned aerial vehicles in land surveying* (MC: ADS = 1.17; LC: ADS = 1.23), and *Interpreting project blueprints* (MC: ADS = 0.41; LC: ADS = 0.44) were the three items in which MC teachers had a lower ADS when compared to the LC teachers (see Table 2).

Table 2

Teachers' Agricultural Mechanics Professional Development Needs by Average Discrepancy Scores (ADS)

	EC (*n* = 38)		*MC* (*n* = 33)		*LC* (*n* = 23)		*Trad. Cert.* (*n* = 56)		*Non-trad. Cert.* (*n* = 38)	
Item	*ADS*	*SD*	*ADS*	*SD*	*ADS*	*SD*	*ADS*	*SD*	*ADS*	*SD*
Principles of metallurgy (ex. identifying metals, proper use of metals, etc.)	1.92	1.14	1.13	1.20	0.71	1.31	1.15	1.29	1.65	1.27
Procedures for structural welding	1.92	1.25	1.10	1.37	0.62	1.25	1.04	1.30	1.70	1.45
American Welding Society (AWS) standards for welding procedures	1.89	1.20	1.03	1.17	1.10	1.31	1.19	1.17	1.70	1.37
Procedures for troubleshooting small engines	1.87	1.53	1.10	1.09	0.45	1.20	1.11	1.34	1.49	1.54
Principles of diesel engine operational theory	1.82	1.43	1.16	1.21	0.77	1.20	1.19	1.27	1.55	1.48
Use of electrical measurement units (ex. amperes, volts, Ohms, etc.)	1.76	1.28	1.16	1.22	0.48	1.22	1.06	1.19	1.53	1.50
Procedures for building metal projects (ex. trailers, barbecue pits, etc.)	1.72	1.28	1.03	1.17	0.24	1.02	0.85	1.16	1.53	1.42
Use of electrical systems tools (ex. digital multi-meter, wire strippers, etc.)	1.70	1.37	1.03	1.18	0.57	1.14	0.98	1.19	1.53	1.46
Principles of electrical theory (ex. conductors, insulators, alternating current [AC], direct current [DC], etc.)	1.70	1.24	0.97	1.09	0.57	0.90	0.98	1.04	1.47	1.38
Procedures for GTAW (TIG welding)	1.65	1.32	1.19	1.28	0.95	1.33	1.06	1.35	1.70	1.22
Procedures for wiring four-way switch circuits	1.63	1.22	0.77	1.28	0.62	1.29	0.96	1.27	1.30	1.41
Procedures for wiring trailer electrical systems	1.63	1.44	0.87	1.12	0.67	1.25	1.00	1.30	1.35	1.42
Principles of welding theory (ex. joint types, positions, etc.)	1.62	1.21	0.77	1.26	0.38	1.00	0.79	1.19	1.38	1.34
Principles of vehicle powertrain operational theory	1.61	1.28	1.13	1.12	0.86	1.14	1.19	1.21	1.37	1.26
Procedures for using unmanned aerial vehicles in land surveying	1.60	1.42	1.17	1.23	1.23	1.44	1.12	1.44	1.69	1.21
Procedures for cold metalworking bending	1.59	1.21	1.00	1.14	0.81	1.33	1.06	1.31	1.42	1.16
Procedures for cold metalworking shaping	1.59	1.21	0.97	1.26	0.76	1.38	1.02	1.38	1.42	1.18
Procedures for reassembling small engines	1.58	1.55	0.93	1.14	0.27	1.25	0.91	1.39	1.24	1.52
Procedures for hot metalworking shaping	1.58	1.22	0.90	1.22	0.62	1.50	0.94	1.38	1.38	1.28
Procedures for wiring outlets	1.57	1.34	1.16	1.30	0.48	1.33	1.02	1.31	1.39	1.48
Procedures for wiring three-way switch circuits	1.55	1.25	0.90	1.19	0.76	1.27	0.98	1.23	1.38	1.32

	EC (*n* = 38)		*MC* (*n* = 33)		*LC* (*n* = 23)		*Trad. Cert.* (*n* = 56)		*Non-trad. Cert.* (*n* = 38)	
Item	*ADS*	*SD*	*ADS*	*SD*	*ADS*	*SD*	*ADS*	*SD*	*ADS*	*SD*
Procedures for hot metalworking bending	1.54	1.30	0.84	1.29	0.57	1.43	0.88	1.41	1.32	1.33
Procedures for plasma arc cutting	1.54	1.17	0.80	1.16	0.43	1.22	0.71	1.16	1.47	1.28
Procedures for wiring single-pole switch circuits	1.53	1.22	1.06	1.21	0.48	1.30	1.02	1.25	1.27	1.37
Procedures for wiring double-pole switch circuits	1.53	1.22	0.94	1.12	0.67	1.28	0.98	1.17	1.32	1.36
Procedures for disassembling small engines	1.53	1.59	0.87	1.07	0.27	1.25	0.89	1.40	1.16	1.50
Procedures for hot metalworking cutting	1.51	1.30	0.88	1.16	0.57	1.40	0.89	1.31	1.33	1.33
Procedures for agricultural equipment operation	1.50	1.45	0.70	1.18	0.45	1.16	0.85	1.29	1.16	1.46
Procedures for cold metalworking cutting	1.49	1.19	0.94	1.13	0.76	1.27	0.96	1.24	1.36	1.17
Principles of four-stroke engine operational theory	1.47	1.35	0.87	1.26	0.50	1.16	0.85	1.25	1.29	1.41
Procedures for conducting land surveys	1.46	1.42	0.67	1.15	0.36	1.37	0.75	1.35	1.14	1.44
Procedures for FCAW (Flux-core arc welding)	1.46	1.45	0.65	1.25	0.60	1.56	0.71	1.54	1.35	1.27
Procedures for oxy-fuel brazing	1.44	1.42	0.65	1.43	0.29	1.35	0.56	1.42	1.36	1.46
Procedures for GMAW (MIG welding)	1.43	1.24	0.71	1.22	0.38	1.17	0.65	1.08	1.32	1.45
Procedures for oxy-fuel welding	1.43	1.44	0.71	1.47	0.19	1.37	0.60	1.45	1.30	1.53
Procedures for using land surveying equipment	1.43	1.36	0.63	1.30	0.45	1.41	0.84	1.41	1.00	1.43
Procedures for oxy-fuel cutting	1.43	1.26	0.52	1.31	0.10	1.19	0.50	1.23	1.22	1.47
Principles of two-stroke engine operational theory	1.39	1.42	0.97	1.14	0.41	1.15	0.91	1.20	1.16	1.48
Use of computer numerical control (CNC) systems	1.34	1.15	1.41	1.34	0.95	1.33	1.19	1.29	1.41	1.24
Procedures for using legal land descriptions	1.34	1.51	0.70	1.21	0.32	1.39	0.86	1.40	0.86	1.51
Procedures for using copper pipe	1.24	1.34	0.42	1.03	-0.10	1.19	0.53	1.26	0.81	1.39
Procedures for using PEX pipe	1.22	1.29	0.78	1.21	0.52	1.33	0.75	1.31	1.11	1.26
Procedures for SMAW (Arc welding)	1.22	1.18	0.65	1.14	0.05	1.13	0.46	1.02	1.14	1.42
Procedures for building masonry projects	1.11	1.29	0.66	1.21	0.05	1.17	0.57	1.27	0.89	1.33
Use of hydraulic equipment (ex. shears, iron worker, etc.)	1.11	1.20	0.63	1.10	0.29	1.24	0.70	1.22	0.81	1.22
Interpreting project blueprints	1.03	0.92	0.41	1.18	0.44	1.26	0.65	1.26	0.72	0.92
Use of precision tools (ex. micrometer, dial caliper, etc.)	0.95	1.27	0.19	1.38	0.00	1.65	0.32	1.52	0.69	1.35
Procedures for laying out projects	0.88	0.96	0.41	0.91	0.11	1.05	0.50	1.15	0.59	0.76
Procedures for using PVC pipe	0.86	1.08	0.13	1.10	-0.33	1.13	0.12	1.08	0.61	1.32
Safety procedures for agricultural mechanics activities	0.85	0.93	0.52	0.78	0.39	0.68	0.54	0.77	0.76	0.94
Drawing project plans to scale	0.85	1.39	0.03	0.98	-0.06	1.35	0.17	1.45	0.63	1.04
Estimating materials for projects	0.82	1.07	0.28	1.10	0.06	1.11	0.45	1.28	0.47	0.88

Item	*EC* (*n* = 38)		*MC* (*n* = 33)		*LC* (*n* = 23)		*Trad. Cert.* (*n* = 56)		*Non-trad. Cert.* (*n* = 38)	
	ADS	*SD*	*ADS*	*SD*	*ADS*	*SD*	*ADS*	*SD*	*ADS*	*SD*
Use of stationary power equipment (ex. band saw, table saw, etc.)	0.79	1.19	0.31	1.06	-0.19	1.14	0.24	1.08	0.62	1.32
Creating a bill of materials for projects	0.79	0.93	0.10	1.14	-0.29	0.96	0.28	1.17	0.34	1.00
Procedures for building fence projects	0.68	1.40	0.03	1.20	-0.62	1.33	0.07	1.40	0.27	1.43
Use of handheld pneumatic (air) tools (ex. impact wrench, paint spray gun, etc.)	0.66	1.24	0.34	1.21	-0.33	1.32	0.09	1.26	0.65	1.30
Procedures for building wood projects	0.63	0.94	0.16	0.99	-0.43	1.26	0.00	1.10	0.54	1.07
Use of laboratory safety equipment (ex. fire extinguishers, eye wash stations, etc.)	0.56	0.79	0.34	1.11	0.22	0.42	0.31	0.66	0.55	1.09
Use of personal protective equipment (PPE)	0.56	0.70	0.28	1.03	0.22	0.42	0.33	0.56	0.45	1.06
Use of measuring tools (ex. tape measure, framing square, etc.)	0.47	0.76	0.41	0.91	0.05	1.10	0.11	0.80	0.72	0.94
Use of fasteners (ex. screws, nails, glue, etc.)	0.47	1.13	0.06	0.96	-0.16	0.87	0.23	1.11	0.12	0.95
Use of handheld power tools (ex. cordless drill, jig saw, etc.)	0.45	0.95	0.45	0.96	-0.16	1.09	0.06	0.89	0.71	1.07
Use of marking tools (ex. chalk line, paint marker, etc.)	0.37	0.88	-0.19	0.97	-0.58	1.27	-0.19	0.94	0.19	1.21
Procedures for painting projects	0.33	1.10	-0.10	1.01	-0.74	1.37	-0.08	1.22	-0.03	1.19
Use of hand tools (ex. screwdriver, hammer, etc.)	0.32	0.70	0.28	0.89	-0.37	1.22	0.04	0.81	0.33	1.10

Note. Importance Scale: 1 [RL = 0 – 1.49] = *Not important* (*NI*), 2 [RL = 1.50 – 2.49] = *Of little importance* (*LI*), 3 [RL = 2.50 – 3.49] = *Somewhat important* (*SI*), 4 [RL = 3.50 – 4.49] = *Important* (*I*), 5 [RL = 4.50 – 5.00] = *Very important* (*VI*); Competence Scale: 1 [RL = 0 – 1.49] = *Not competent* (*NC*), 2 [RL = 1.50 – 2.49] = *Little competence* (*LC*), 3 [RL = 2.50 – 3.49] = *Somewhat competent* (*SC*), 4 [RL = 3.50 – 4.49] = *Competent* (*C*), 5 [RL = 4.50 – 5.00] = *Very competent* (*VC*); *ADS* = Average discrepancy score; *SD* = Standard deviation.

Teachers who indicated they earned their teacher certification via a non-traditional route had a higher ADS for 63 out of the 65 items included in this study. Teachers of both certification routes (i.e., traditional and non-traditional) had the same ADS (0.86) on the item *Procedures for using legal land descriptions* and traditionally-certified teachers had a higher ADS on the item *Use of fasteners (ex. screws, nails, glue, etc.)* (ADS = 0.23).

With an ADS of 1.19, the largest training needs of the traditionally-certified teachers were associated with: *American Welding Society (AWS) standards for welding procedures*, *Principles of diesel engine operational theory*, *Principles of vehicle powertrain operational theory*, and *Use of computer numerical control (CNC) systems*. The topics in which non-traditionally-certified teachers indicated the highest levels of training needs were: *Procedures for structural welding* (ADS = 1.70), *American Welding Society (AWS) standards for welding procedures* (ADS = 1.70), and *Procedures for GTAW (TIG welding)* (ADS = 1.70).

To assess objective three, we conducted a 3 (teacher career phase) x 2 (teacher certification route) factorial ANOVA to examine the effects of teacher career phase and teacher certification route on agricultural mechanics PD needs (i.e., MDS). We tested the assumptions of the factorial ANOVA by performing residual analysis. The data in our study were normally distributed as assessed by Shapiro-Wilk's test ($p > .05$). We did not identify the presence of outliers based on our examination of boxplots and studentized residuals. We found there was homogeneity of variances as assessed by Levene's test for equality of variances, $p = .857$.

There was not a statistically significant interaction between teacher career phase and teacher certification route for the MDS of the teachers, $F(2, 88) = .384$, $p = .682$. We failed to reject the first (H_o1) null hypothesis. Field (2018) posited that when an interaction effect is not statistically significant, the main effects included in the two-way ANOVA should be explored (see Table 3).

Table 3

Factorial ANOVA Source Table of Main and Interaction Effects of Teacher Career Phase and Teacher Certification Route on the Dependent Variable of Teachers' MDS Associated with Agricultural Mechanics PD Needs

Source	*SS*	*df*	*MS*	*F*	*p*	η_p^2
Corrected Model	17.099	5	3.420	4.722	0.001	-
Intercept	54.029	1	54.029	74.608	0.000	-
CERT	2.648	1	2.648	3.656	0.059	-
Career Phase	13.038	2	6.519	9.002	0.000	0.170
Career Phase x CERT	0.556	2	0.278	0.384	0.682	-
Error	63.727	88	0.724			
Total	146.647	94				

Note. $p < .05$; CERT = Teacher certification route. The reported measures of central tendency and dispersion associated with this analysis can be accessed in Table 1.

The main effect of teacher certification route on agricultural mechanics PD needs was not significant, $F(1, 88) = 3.656$, $p = .059$. We failed to reject the second null hypothesis (H_o2). The main effect of teacher career phase on agricultural mechanics PD needs was significant, $F(2, 88) = 9.0002$, $p < .001$, $\eta_p^2 = .170$; thus, we rejected the third null hypothesis (H_o3). The effect size ($\eta_p^2 = .170$) for the main effect of teacher career phase was between medium and large (Cohen, 1988). We used a Bonferroni *post hoc* test and found that the overall agricultural mechanics PD needs were significantly lower for MC teachers (M = 0.82, SD = 0.94) in comparison to EC teachers (M = 1.34, SD = 0.93; see Table 4).

Table 4

Comparison of Teachers' Agricultural Mechanics PD Needs Based Upon the Bonferroni Post Hoc Test

Group	*n*	M^1	*SD*
EC teachers	28	$1.34^{a,b}$	0.93
MC teachers	32	0.82^{a}	0.94
LC teachers	30	0.45^{b}	0.69

Note. [1] = Subscripts with differing letters are significantly different at $p < .05$; *M* = Mean; *SD* = Standard deviation.

We further found that the overall agricultural mechanics PD needs were significantly lower for LC teachers (*M* = 0.45, *SD* = 0.69) when compared to EC teachers (*M* = 1.34, *SD* = 0.93).

Conclusions, Discussion, Recommendations, and Limitations

The purpose of our study was to examine potential differences in teachers' agricultural mechanics PD needs based on teacher career phase and teacher certification route. Our findings indicate that agriculture teachers across the United States: (1) do not have statistically significant differences in their agricultural mechanics PD needs based on teacher certification route and (2) do have statistically significant differences in their agricultural mechanics PD needs based on teacher career phase. We further identified that both MC teachers and LC teachers have a reduced need for agricultural mechanics PD in comparison to EC teachers. Burris et al. (2010) posited that in-service agriculture teachers' confidence teaching agricultural mechanics tends to increase as they gain additional experience teaching the subject matter area. Thus, this finding was not unexpected. Our findings align with others scholars' works (i.e., Sorenson et al., 2014; Yopp et al., 2020) and add to the substantial body of literature regarding agriculture teachers' PD needs.

In the context of developing human capital (Becker, 1993), our study provided specificity regarding differences in teachers' agricultural mechanics PD needs. Thus, our study is useful for helping the profession to develop and implement more robust and appropriate PD to serve agriculture teachers. Human capital development is fundamental to societal progress (Becker, 1993; Olaniyan & Okemakinde, 2008). Providing PD opportunities through which to appropriately develop human capital is important to the progression of Agricultural Education as well (Thoron et al., 2016). Considering human capital development needs, DiBenedetto et al. (2018) noted that "[t]eacher educators should plan experiences that… relate to a variety of audiences, dependent upon career stage and type of certification" (p. 67). Bearing in mind DiBenedetto et al.'s (2018) advice, our study should serve as a point of reference for others who plan agricultural mechanics PD opportunities for agriculture teachers in the future.

Considering the aforementioned discrepancies between the different teacher groups' agricultural mechanics PD needs, we found both comfort and causes for concern. For example, both LC and MC teachers exhibit similar (albeit minimized) PD needs regarding the *Use of handheld power tools (ex. cordless drill, jig saw, etc.)* while MC teachers indicated that they had greater PD needs related to the *Use of computer numerical control (CNC) systems*. This indicates that these groups of teachers are both well-prepared to work with handheld power tools; however, MC teachers may not be as well-prepared to use CNC systems in their programs.

It is conceivable that a technological use gap may exist between the teachers in each career phase. For example, EC teachers may be more likely to attempt to use computerized system-dependent CNC systems versus MC teachers. Moreover, perhaps differences in agricultural teacher education programming may have yielded such variance. The number of agricultural mechanics-related credit hours required by agricultural teacher education programs has declined in recent decades. Across the same timeframe, however, the diversity of topics taught within university-level agricultural mechanics courses has increased (Granberry et al., 2023). Thus, perhaps younger teachers may have received exposure to some agricultural mechanics topics that their older counterparts did not. Scholars should consider following-up on these notions in future research. Doing so may yield additional insights into the changing landscape of teaching agricultural mechanics.

We found it interesting that while we did not identify statistically significant differences in teachers' agricultural mechanics PD needs based on teacher certification route, there were some noticeable differences nonetheless. Teachers who had earned their certification via a non-traditional route has a higher ADS on 63 of the 65 agricultural mechanics items, thus indicating that they had a greater need for agricultural mechanics PD in those topics. This finding was interesting to us, as other scholars who have studied differences in PD needs based on teacher certification route (i.e., Stair et al., 2019) found that alternatively-certified agriculture teachers in Louisiana reported lesser need for agricultural mechanics PD in comparison to their traditionally-certified colleagues. Thus, our findings conflict with prior literature. Because they did not complete a traditional agricultural teacher education program prior to becoming agriculture teachers, perhaps the non-traditionally-certified teachers in our study had limited exposure to agricultural mechanics beforehand. We did not ask our respondents to provide information regarding their own experiences with agricultural mechanics before becoming agriculture teachers. Perhaps scholars who elect to study this topic in the future should consider doing so.

In contrast to Sorensen et al. (2014), who indicated that agriculture teachers' overall agricultural mechanics PD differ based on teacher career phase, we sought to provide a deeper, granular lens for determining if PD needs differ in various subject matter areas (e.g., structures, metal fabrication, power mechanics) within the broader scope of agricultural mechanics. We believe that our approach to exploring this topic yielded data that are, in essence, more beneficial to Agricultural Education stakeholders, especially those who plan and deliver agricultural mechanics PD, such as agricultural teacher educators who teach agricultural mechanics courses, in-service agriculture teachers with expertise in agricultural mechanics, and outdoor power equipment industry representatives. Specifically, such stakeholders can use our data to target specific audiences based on teacher career phase, thereby assisting those agriculture teachers who are most likely to benefit from intentionally-designed, well-focused agricultural mechanics PD. Moreover, our granular lens approach also provided data regarding particular topics that Agricultural Education stakeholders should work to address in the coming years. Considering the need for well-trained human capital in American public schools (Myung et al., 2013) and that high-quality, effective PD should be differentiated to better-address individual teachers' interests and needs (Gabriel, 2010), we believe our study is timely and is of value to our profession.

Despite our response rate of 27.5%, we found that nonresponse error was not a limitation of our study. Thus, in accordance with Lindner et al. (2001), we can generalize our findings to the whole population of agriculture teachers across the United States. Regarding limitations, however, perhaps the most significant limitation to our study was the lack of information regarding teachers' gender identity. We did not collect these data within our 72-item instrument. Doing so would have added another demographic factor to our data analysis, which could have yielded further insight into differences in teachers' agricultural mechanics PD needs and thus made a more robust contribution to the agricultural teacher education literature. Prior research (Li, 2016) has indicated that teachers' gender identity can play a role in their PD needs. As such, we advise that scholars who wish to use our instrument in the future should add at least one item inquiring about teachers' gender identity to the teacher demographics section of our instrument. Moreover, to help reduce the potential for respondent fatigue that can result from lengthy instruments (Dillman et al., 2014), we chose not to ask respondents to report either the topics they teach within their agricultural mechanics courses or their prior experiences with agricultural mechanics before becoming agriculture teachers. Scholars who seek to explore this and similar topics in the future should consider how to strategically gather these data without fatiguing potential respondents out.

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