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# An Evaluation of the Knowledge, Performance, and Consequence Competence in a Science, Technology, Engineering, and Mathematics (STEM) Based Professional Development for School-based Agricultural Science Teachers: An Assessment of an Industry Supported Computer Numerical Control (CNC) Plasma Arc Cutting Workshop

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## Abstract

Curriculum reform since 1915 has positioned agricultural education as an applied science that combines principles of the physical, chemical, and biological sciences in the production and processing of food and fiber. The agricultural mechanics laboratory is an integral part of agricultural education programs, and instructors are spending a great amount of instructional time in the agricultural mechanics laboratory. Educators have a responsibility to instruct students regarding these specific skills, thus identifying the specific professional development needs of agricultural mechanics instructors can be difficult. The Borich needs assessment model served as the conceptual framework for this study while instrumentation and research objectives were guided by two theories: Bandura's theory of self-efficacy and Knowles theory of andragogy. Agricultural science teachers from across Texas attended a professional development workshop focused on CNC plasma cutting principles, software, and technology use. Results indicated teachers had professional development needs across all 26 CNC plasma arc cutting competencies and the workshop was effective in lowering these needs based upon a mean weighted discrepancy score. Additionally, when evaluating pre- and post-measures across four summated scales, the importance, knowledge, and ability levels all increased positively.

***Keywords*:** Computer numerical control, plasma arc cutting, professional development, career and technology education, Borich needs assessment model

## Introduction/Literature Review

At the inception of school-based agricultural education programs in the early 1900s, the focus of programs was primarily centered on production agriculture with the ultimate goal of preparing students to return to the farm or pursue a career in production agriculture (Leake, 1915). Curriculum reform since 1915 has positioned agricultural education as an applied science combining principles of the physical, chemical, and biological sciences in the production and processing of food and fiber (Conroy & Kelsey, 2000). The modern agricultural education model has three main components: classroom and laboratory instruction, supervised agricultural experiences, and intracurricular activities, better known as the FFA (Croom, 2008). However, the classroom/laboratory component of agricultural education often times does not look like a typical academic setting. The agricultural mechanics classroom and laboratory offer unique experiences for many students, providing real world engagement in the context of a safe learning environment (Langley & Kitchel, 2013).

The modern agricultural mechanics laboratory is an integral part of many agricultural education programs (Phipps, Osborne, Dyer, & Ball, 2008) and can provide real world experiences in a safe learning environment (Langley & Kitchel, 2013). Likewise, Saucier, Terry, & Schumacher (2009) found Missouri agricultural educators spent almost 10 hours per week supervising students in these unique learning environments. In the agricultural mechanics laboratory, students are exposed to metalworking, woodworking, agricultural machinery, chemicals, compressed gasses, and electrical equipment. Each one of these categories has aspects that are potentially dangerous when not used as prescribed by the manufacturer (Johnson & Schumacher, 1989). Despite the potentially dangerous environment involved within the agricultural mechanics laboratory, instructors are spending a great deal of instructional time in the agricultural mechanics laboratory (Blackburn, Robinson, & Field, 2015; Chumbley, Gill, &

Chesher, 2013; Hubert, Ulrich, Murphy, & Lindner, 2001). Further, agricultural mechanics continues to be one of the most enrolled in curriculum areas by students and one of the most popular courses offered at the high school level (Hubert & Leising, 2000). Despite having agricultural mechanics course enrollment numbers topping 28,000 in Texas during the 2014 school year, current pre-service teachers are required to take fewer preparatory classes related to agricultural mechanics than in years past. Burris, Robinson, and Terry (2005) reported agricultural education programs generally required between 5 and 8 hours of agricultural mechanics courses in teacher preparation programs. Consequently, several studies have indicated school-based educators had not received adequate agricultural mechanics education prior to entering the laboratory (Burris et al., 2005; Dyer & Andreasen, 1999; Swan, 1992).

Additionally, educators have a responsibility to educate students regarding the skills employers require (Garton & Robinson, 2006). Not only do teachers need to provide skill education, but teachers must continually adjust curriculum to fit local needs (Roberts & Ball, 2009). However, according to Saucier and McKim (2011), identifying the in-service needs of agricultural educators can be difficult. Possibly more difficult though is identifying specific needs of agricultural mechanics instructors. Not unlike other facets of agriculture, mechanical agriculture encompasses a wide range of skills and competencies. Due to the nature of agricultural mechanics instruction, it is no wonder why some teachers lack confidence in the subject area (Blackburn et al., 2015). As such, teachers possess skill sets with a wide range of ability, have different background knowledge of agricultural mechanics, and often need professional development in various areas of focus (Huberman, 1993). Teachers are often provided professional development regarding large overarching goals of an institution and usually do not include techniques or skills focused on a particular discipline (Huberman, 1993). Further, Garton and Chung (1996) found teachers needs were not always identified correctly by those outside the specific teaching field. Therefore, teachers practicing in the specific area where professional development is to be implemented should be involved in the process guiding the development of the professional development.

Science, Technology, Engineering, and Mathematics (STEM) principles have been a part of agricultural education predating the Smith-Hughes Act of 1917 (Newman, 2017). However, specific instruction highlighting the components of STEM have historically been a struggle for agricultural educators (Fleischman, Hopstock, Pelczar, & Shelley, 2010). Consequently, teachers have suggested STEM may be a new educational phrase, and may not have long-term viability. This notion does have some merit. Since the 1970's, calls for education targeting STEM areas have been echoed through every discipline in education. Specifically many of the STEM educational goals are near mirror images of the educational goals of agricultural education. Although there are some hurdles when it comes to STEM integration, the already close relationship between agriculture and STEM could mean agricultural educators are well suited in providing a needed workforce for not only agriculture, but also all industries where STEM careers exist (Stubbs & Myers, 2016).

Agricultural education goals are not the only evidence suggesting agricultural education may be a mechanism to promote STEM. The U.S. Department of Education defined five areas where STEM principles already exist. Agricultural sciences and computer information systems were included along with mathematics and engineering (Chen, 2009). Stubbs and Myers (2016) asserted student achievement levels in science courses improved when specific STEM integration techniques were used while in agricultural education courses. Additionally, teachers indicated without prior experience in specific areas of STEM, integration was more difficult.

Specifically, teachers with little to no engineering experiences lacked explicit knowledge of STEM integration, and some shared negative perceptions of mathematical competencies (Stubbs & Myers, 2016). One way to help teachers gain insight into mathematical and engineering principles is to provide professional development programs rich in these skills.

## Conceptual Framework

The conceptual framework for this study was derived from the needs assessment model developed by Borich (1980). The fundamental concept of the Borich needs assessment model is to allow teaching and research to be developed based on the most needed area first. Since the inception of the Borich model in 1980, countless studies both inside and outside of agricultural education, have used the model to evaluate teachers self-perceived competence, in relation to a single competency (Sorenson, Lambert, & McKim, 2014). However, the Borich model posited there are three areas a person develops competence from: knowledge, performance, and consequence. Each competence yields, for each respondent, "three discrepancy scores that indicate the effectiveness of the training program in producing (a) trainee knowledge, (b) trainee performance, and (c) pupil consequence" (Borich, 1980, p. 40). The resulting discrepancy scores can be considered unique assessment dimensions (i.e., knowledge, performance, and consequence). The definitions for each area can be viewed in Table 1.

Table 1. Borich (1980, p. 40) Needs Assessment Model Competencies

| Competency Construct | Definition |
|---|---|
| Knowledge Competence | Ability to accurately recall, paraphrase, or summarize the procedural mechanics of the behavior on a paper and pencil test |
| Performance Competence | Ability to accurately execute the behavior in a real or simulated environment in the presence of an observer |
| Consequence Competence | Ability to elicit learning from pupils by using the behavior in the classroom |

The fundamental concept of the Borich (1980) needs assessment model is to allow teaching and research to be developed based on the most needed area first. As such, researchers may derive competencies from a number of places: existent research, literature, industry standards, laws, professional societies, and stakeholder groups (Borich, 1980). This study utilized two of the suggested areas to develop competencies: current research related to agricultural mechanics instruction and stakeholder group input.

The conceptual example in Figure 1 (Saucier, McKim, Muller, & Kingman, 2014) depicts how an individual (i.e. teacher) may respond differently to each type of competence by dimension. Each competency yields, for each respondent, "three discrepancy scores … that indicate the effectiveness of the training program in producing (a) trainee knowledge, (b) trainee performance, and (c) pupil consequence" (Borich, 1980, p. 40). The resulting discrepancy scores can be considered unique assessment dimensions (i.e., knowledge, performance, and consequence).

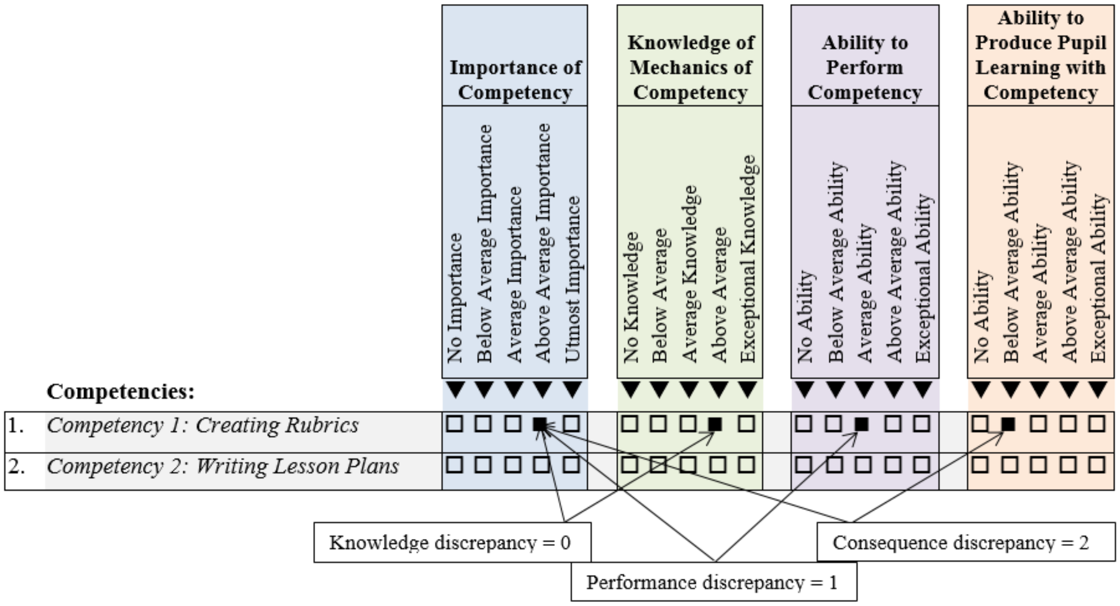


***Figure 1***. An example of how knowledge, performance, and consequence discrepancies may differ, even when based on the same competency item (Borich, 1980; Saucier et al., 2014).

Saucier et al. (2014) explained that among the dimensions found within the model, the ranking of a competency might vary. As displayed in Figure 1, a knowledge discrepancy = 0, performance discrepancy = 1, and consequence discrepancy = 2. It is important to note, the numerical differences between dimensions are not absolute or interval in nature (i.e. a consequence discrepancy of 2 is not twice the value of a performance discrepancy of 1). Since *Importance of Competency* is included into each dimension, a competency can be relatively compared by discrepancy across dimensions. When a teacher considers the *creating rubrics* competency (see Figure 1), the need to prioritize how to teach others to *create rubrics* (consequence discrepancy) may be more important to include in a training program than the mechanics of creating rubrics (knowledge discrepancy).

Furthermore, competencies may also vary within dimensions. As noted in Figure 2, knowledge competence for an item could be ranked highest, whereas, the same item may be ranked lowest for consequence competence and within a mid-range for performance competence. Therefore, both factors of dimensions (among and within) should be contemplated when deciding the focus of a training program (McKim, 2013).

## Theoretical Framework

To better understand the professional development needs of career and technology educators in the technical curriculum area of computer numerical control (CNC) plasma arc cutting technology, two theories were used to develop the theoretical base for this non-experimental, quantitative study: Knowles' theory of andragogy and Bandura's theory of self-efficacy (Bandura, 1997). Knowles' theory of andragogy (Knowles, Holton III, Swanson, 2005) proposed that the adult learner must know why they must know a concept. This knowledge will then likely motivate them to engage in the learning process. Furthermore, adults learn experientially, learn as problem solvers, and learn best when the topic is of immediate value to them.

*Rankings of Competencies by Dimension*

| Knowledge | Performance | Consequence |
|---|---|---|
| **Competency 1** | Competency 4 | Competency 4 |
| Competency 3 | Competency 2 | Competency 3 |
| Competency 4 | **Competency 1** | Competency 2 |
| Competency 2 | Competency 3 | Competency 5 |
| Competency 5 | Competency 5 | **Competency 1** |

***Figure 2***. A multi-dimensional assessment of competency enables teacher educators to identify the competencies and the dimension (knowledge of the competency, ability to perform the competency, and/or the ability to teach the competency) needing to be addressed (Saucier et al., 2014).

Knowles (1983) also determined that adults should be engaged in the development of their own learning experiences, thus becoming self-directed. Concluding a review of literature, numerous studies found the theory of andragogy has been linked to successful engagements between science, research, and technology. Cantwell (1999) found when employees were required to conduct face-to-face contacts when communicating the results of complex learning processes, positive performance resulted amongst employees, thus building increased social capital (Kessels & Peoll, 2004). Similar to the workers described in these studies, career and technology teachers can gain from improvements in knowledge of technology and associated research, peer communication (i.e. building social capital), and learning complex processes (i.e. CNC plasma arc cutting technology innovations).

Self-efficacy has been defined as the "beliefs in one's capabilities to organize and execute the course of action required to produce given attainments" (Bandura, 1997, p. 3). Bandura (1986) found that self-efficacy influences a person's choices, actions, the amount of effort they give, how long they persevere when faced with obstacles, their resilience, their thought patterns and emotional reactions, and the level of achievement they ultimately attain. See Figure 3 for an illustration of the theory.

To further understand the professional development needs of career and technology teachers, researchers must also understand self-efficacy levels of the teacher (choices, actions, effort given, perseverance level, resilience, thought patterns and emotional reactions, and level of achievement) and the most effective ways to educate those teachers (Bandura, 1997; Knowles, 1983). In the curriculum area of CNC plasma arc cutting technology, future professional development opportunities should be planned, delivered, and evaluated by educators and state agricultural education leaders, based upon these educational theories. Due to the limited amount of research regarding the professional development needs of Texas career and technology teachers (agricultural education) in the curriculum area of CNC plasma arc cutting technology, and the continual need for research regarding professional development of these specialized teachers on a national level (Lambeth, Elliot, & Joerger, 2008; Roberts, Harder, & Brashears, 2016), a current assessment of these needs is warranted and should be conducted.

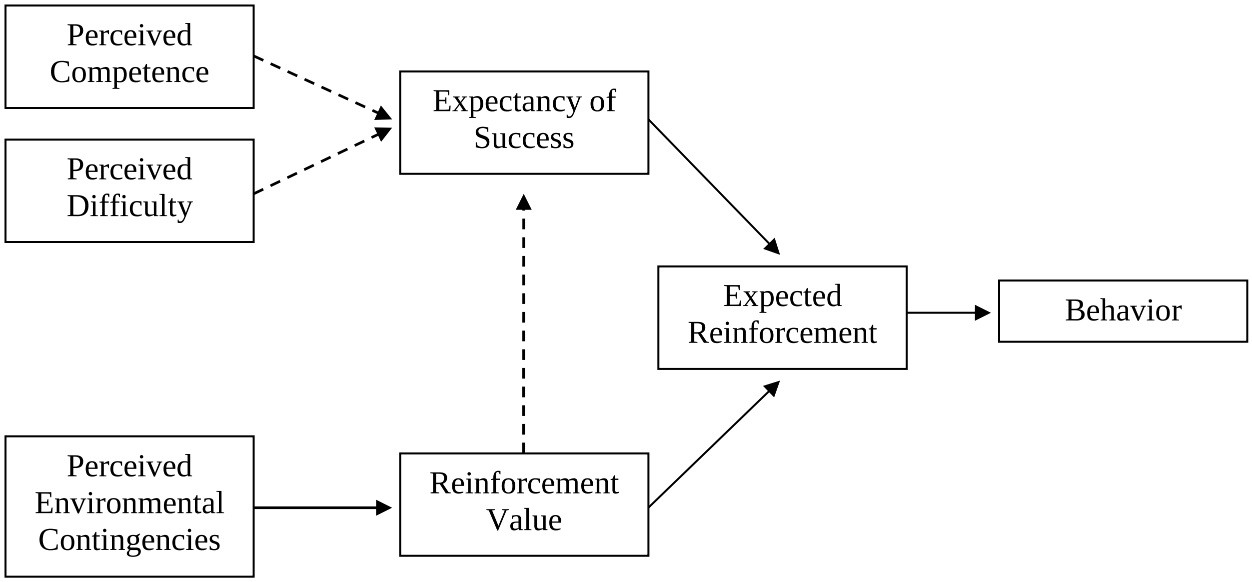


***Figure 3.*** An illustration of the theory of self-efficacy (Bandura, 1997)

## Purpose and Research Objectives

The purpose of this evaluation was to determine the self-perceived efficacy levels of teachers (*n* = 19) concerning 26 industry supported CNC plasma arc cutting technology competencies instructed during the Tarleton State University CNC plasma arc cutting technology professional development workshop (CNCPD) in the summer of 2015, determine if change occurred in participants' self-perceived efficacy levels of knowledge, performance, and teaching competence regarding the CNCPD competencies, and identify the professional development needs of the workshop participants based upon the CNCPD competencies instructed. The following research objectives guided this study:

1) Describe the change in participants' perceived importance of teaching CNCPD competencies based on pre- and post-test scores.
2) Describe the change in participants' knowledge of CNCPD competencies based on pre- and post-test scores.
3) Describe the change in participants' ability to perform the CNCPD competencies based on pre- and post-test scores.
4) Describe the change in participants' ability to teach the CNCPD competencies based on pre- and post-test scores.
5) Describe the change in participants' perceived professional development needs related to participants' perceptions of the importance, knowledge, ability to perform, and ability to teach CNCPD competencies, based on pre- and post-test construct scores.

## Methods

This quantitative, descriptive evaluation was conducted in the summer of 2015 at Tarleton State University. The population for this study were all Texas school-based agricultural science teachers who attended a CNCPD ($n$ = 21). The overarching construct of this study was to measure perceptions of teachers' knowledge to teach (Knowledge Competence), their ability to perform (Performance Competence), and teach (Consequence Competence) CNCPD competencies. A review of the literature did not reveal an obvious data collection instrument. Hence, a two-section instrument to address the research objectives of this study was developed by the researchers from the 26 industry supported curriculum competencies taught during the workshop.

Following Borich's (1980) and Borich and Fenton's (1977) recommendations, the competencies used in this study were drawn from workshop competencies. More specifically, the 26 CNCPD addressed in the three-day professional development workshop were derived by consulting two areas of stakeholders: teaching professionals using CNC plasma arc cutting technology and industry experts using CNC plasma arc cutting technology who employ graduates with the ability to use CNC plasma arc cutting technology. The first section of the instrument consisted of a quadruple-matrix containing 26 statements representing the areas indicated by the stakeholder group. The 5-point, summated rating scale was designed upon suggestions by Dillman, Smyth, and Christian (2014) and Spector (1992) and was associated with each of the four matrices. These matrices allowed workshop participants a chance to respond to each statement four times. When responding to the first matrix, participants were asked to indicate their *level of importance to teach* for each competency. For the second matrix, participants were asked to indicate their *level of knowledge* concerning each competency. In the third and fourth matrices, participants were asked to rate their *ability to perform* each competency and their *ability to teach students* how to perform each competency. The second section sought to identify individuals' demographic characteristics (i.e., age, ethnicity, years of teaching experience, university semester credit hours completed in agricultural mechanics, hours spent supervising students in the agricultural mechanics laboratory, etc.).

The design and format of the paper type, data collection instrument were guided by the suggestions of Dillman et al., (2014) and Spector (1992). The paper questionnaire was created and distributed to a panel of experts ($N$ = 7) to assess face and content validity. The panel of seven experts consisted of faculty members from university level agricultural education and agricultural systems management programs (3), secondary agriculture mechanics teachers (2), and industry stakeholders (2). Due to no pre-existing population being available who had participated in a CNCPD, post-hoc reliability measures were calculated (Cronbach's alpha coefficients) for the scales of measurement—importance, knowledge, ability to perform, ability to teach—reliability indices were generated using the participants pre-CNCPD responses and yielded coefficients of .93 and .98 ($n$ = 19).

Pre-CNCPD data were collected by inviting participants ($N$ = 21) to complete the paper questionnaire, proctored immediately before the workshop activities began; 19 participants completed the pre-CNCPD questionnaire. Similarly, participants were invited to complete the paper questionnaire, proctored at the conclusion of CNCPD activities; 19 participants completed the post-CNCPD questionnaire. A summarized description of CNCPD participants are provided in Tables 2 & 3.

Table 2. Selected Demographics of Agricultural Science Teachers who Participated in CNCPD (n = 19)

| Characteristic | *M* | *SD* | Min | Max |
|---|---|---|---|---|
| Years of teaching experience | 10.50 | 10.20 | 1 | 34 |
| Age of participants | 35.56 | 13.02 | 23 | 53 |
| Hours worked per week | 63.06 | 12.14 | 50 | 90 |

Table 3. Selected Demographics of Agricultural Science Teachers who Participated in CNCPD (n = 19)

| Characteristics | *f* | *%* |
|---|---|---|
| Sex | | |
| Male | 14 | 73.7 |
| Female | 5 | 26.3 |
| Ethnicity | | |
| White | 18 | 94.7 |
| Hispanic/Latino | 1 | 5.3 |
| American Indian/ Native American | 0 | 0.0 |
| Asian/Pacific Islander | 0 | 0.0 |
| African American/ Black | 0 | 0.0 |
| Other | 0 | 0.0 |

## Data Analysis

Research objectives one, two, three, and four sought to describe the change in participants' perceived importance of teaching CNC Plasma Arc Cutting technology workshop (CNCPD) competencies, their knowledge of the CNCPD competencies, and their ability to perform and teach the CNCPD competencies, based on pre- and post-test scores. To analyze data for research objective one, two, three, and four, mean weighted discrepancy scores (MWDS) were calculated using a Microsoft™ Excel-based MWDS calculator (McKim & Saucier, 2011) based on the following formula:

$$MWDS = \frac{\sum[M_{Associated\ Importance\ Rating}\ (\text{Importance} - \text{Dimension Ability})]}{n} \quad (1)$$

where $M_{\text{Associated Importance Ratings}}$ refers to the mean associated with each competency or item, Importance refers to the self-perceived importance a respondent views a competency using a Likert-type scale, and dimension ability refers to Knowledge (*Knowledge of Competency*), Performance (*Ability to Perform Competency*), or Consequence (*Ability to Produce Pupil Learning with Competency*).

Based upon recommendations found in Borich's work, corresponding changes in MWDSs, between pre- and post-assessments were reported. Larger MWDSs represent greater in-service needs; whereas, smaller scores represent lesser in-service needs (Borich, 1980).

Research objective five sought to describe the professional development needs related to participants' perceptions of knowledge, performing, and teaching the CNCPD competencies. To analyze data for this research objective, IBM SPSS Statistics 22.0 was used to calculate measures of central tendency for each scale of measurement: importance, knowledge, ability to perform, and ability to teach others to perform.

## Findings

Research objectives one, two, three, and four sought to describe the change in participants' perceived importance of teaching CNCPD competencies, their knowledge of the CNCPD competencies, and their ability to perform and teach the CNCPD competencies, based on pre- and post-test scores. The CNCPD competencies were initially ranked based on the Pre-CNCPD MWDS.

When focusing on the *Knowledge Competence* in the pre-evaluation, participants indicated having the greatest in-service need regarding *machine code software operation (SheetCam)-tool set up* (MWDS = 8.11). However, participants indicated having the least amount of need for in-service related to *safety–dust control* (MWDS = 1.18). During the post evaluation, the CNCPD participants indicated to have the greatest in-service need as it related to *control software operation (Mach 3)–troubleshooting* (MWDS = 6.39). Furthermore, the participants had the least in-service need regarding *safety–automated movement awareness* (MWDS = 1.99). Overall, participants had the greatest negative change in MWDS in regards to *control software operation (Mach 3)–real time machine adjustment* (Δ -3.51). Consequently, the post-CNCPD participants indicated the largest positive change in MWDS as *safety–dust control* (Δ + 1.59). To further describe the self-perceived *Knowledge Competence* professional development needs of participants in regards to the CNCPD, please see Table 4.

The *Performance Competence* in-service needs (pre & post) and change regarding in-service needs are displayed in Table 5. During the pre-evaluation, participants indicated having the greatest in-service need regarding *machine code software operation (SheetCam)–tool set up* (MWDS = 9.07). However, participants also indicated they had the least need for in-service as related to *safety–dust control* (MWDS = 1.18). Post evaluation CNCPD, participants indicated to have the greatest in-service need as it related to *machine code software operation (SheetCam)–tool set up* (MWDS = 6.96). Furthermore, the participants had the least in-service need regarding *safety – automated movement awareness* (MWDS = 1.99). Overall, participants had the greatest negative change in MWDS in regards to *control software operation (Mach 3)–manual movement* (Δ -4.18). Consequently, the post-CNCPD participants indicated the largest positive change in MWDS as related to *safety–dust control* (Δ + 1.59). For an additional description of the self-perceived *Performance Competence* professional development needs of participants in regards to the CNCPD, see Table 5.

Table 4. Knowledge Competence Mean Weighted Discrepancy Scores (MWDS) from Pre and Post CNC Plasma Cutting Technology Workshop Evaluations (n = 19)

| | Pre | | Post | | Δ |
|---|---|---|---|---|---|
| Competencies | Rank | MWDS | Rank | MWDS | MWDS |
| Machine Code Software Operation (SheetCam)–Tool Setup | 1 | 8.11 | 2 | 6.18 | -1.93 |
| Drafting Software Operation (V-carve)–Basic Part Design | 2 | 8.02 | 5 | 5.15 | -2.87 |
| Control Software Operation (Mach 3)–Trouble-shooting | 3 | 7.80 | 1 | 6.39 | -1.41 |
| Control Software Operation (Mach 3)–Real time machine adjustment | 4 | 7.45 | 11 | 3.94 | -3.51 |
| Machine Code Software Operation–Part Placement | 5 | 7.23 | 3 | 5.80 | -1.43 |
| Drafting Software Operation (V-Carve) 2-D Drafting-Connecting Basic Vectors | 6 | 7.21 | 9 | 4.38 | -2.83 |
| Drafting Software Operation (V-carve) Basic Part Design | 7 | 7.09 | 7 | 4.54 | -2.55 |
| Control Software Operation (Mach 3)–Basic machine functions | 8 | 6.90 | 6 | 4.64 | -2.26 |
| Control Software Operation (Mach 3)–Manual Movement | 8 | 6.90 | 19 | 2.71 | -4.19 |
| Drafting Software Operation (V-Carve) 2-D Drafting of Basic Shapes | 10 | 6.67 | 13 | 3.49 | -3.18 |
| Machine and Software Operation–Drafting Software Operation (V-carve) Drawing Layer Setup | 11 | 6.64 | 10 | 4.19 | -2.45 |
| Machine Code Software Operation (SheetCam)–Basic Setup (machine size, material size, working envelope) | 12 | 6.56 | 4 | 5.61 | -0.95 |
| Drafting Software Operation (V-carve) Using Text in a Design | 13 | 6.49 | 7 | 4.54 | -1.95 |
| Plasma Unit Setup–Ventilation System | 14 | 6.14 | 16 | 3.06 | -3.08 |
| Plasma Unit Setup–Air Filtration | 15 | 5.06 | 21 | 2.59 | -2.47 |
| Material Finishing–Material Choice | 16 | 4.92 | 20 | 2.67 | -2.25 |
| CNC Table Setup–Table Leveling | 17 | 4.69 | 14 | 3.45 | -1.24 |
| CNC Table Setup–Physical Placement | 18 | 4.52 | 14 | 3.45 | -1.07 |
| Plasma Power Unit Setup–Physical Placement | 19 | 4.46 | 12 | 3.93 | -0.53 |
| Material Finishing–Dross Removal | 20 | 4.16 | 17 | 2.98 | -1.18 |
| Safety–Fume Control | 21 | 3.91 | 24 | 2.22 | -1.69 |
| Safety–Automated Movement Awareness | 22 | 3.57 | 26 | 1.99 | -1.58 |
| Safety–Fire Hazard | 23 | 2.70 | 22 | 2.34 | -0.36 |
| Safety–Arc Flash | 24 | 2.18 | 25 | 2.08 | -0.10 |
| Safety–Thermal Burn | 25 | 1.92 | 23 | 2.32 | +0.40 |
| Safety–Dust Control | 26 | 1.18 | 18 | 2.77 | +1.59 |

*Note:* The higher the MWDS, the greater the need for professional development

Table 5. Performance Competence Mean Weighted Discrepancy Scores (MWDS) from Pre and Post CNC Plasma Cutting Technology Workshop Evaluations (n = 19)

| | Pre | | Post | | Δ |
|---|---|---|---|---|---|
| Competencies | Rank | MWDS | Rank | MWDS | MWDS |
| Machine Code Software Operation (SheetCam)–Tool Setup | 1 | 9.07 | 1 | 6.96 | -2.11 |
| Drafting Software Operation (V-carve)–Basic Part Design | 2 | 8.72 | 5 | 5.93 | -2.79 |
| Drafting Software Operation (V-Carve) 2-D Drafting–Connecting Basic Vectors | 3 | 8.32 | 9 | 4.64 | -3.68 |
| Machine Code Software Operation–Part Placement | 4 | 7.93 | 3 | 6.55 | -1.38 |
| Control Software Operation (Mach 3)–Real time machine adjustment | 5 | 7.89 | 12 | 3.94 | -3.95 |
| Control Software Operation (Mach 3)–Trouble-shooting | 6 | 7.80 | 2 | 6.92 | -0.88 |
| Control Software Operation (Mach 3)–Basic machine functions | 7 | 7.62 | 6 | 5.41 | -2.21 |
| Drafting Software Operation (V-carve) Using Text in a Design | 8 | 7.54 | 8 | 5.04 | -2.50 |
| Drafting Software Operation (V-carve) Basic Part Design | 9 | 7.46 | 7 | 5.29 | -2.17 |
| Drafting Software Operation (V-Carve) 2-D Drafting of Basic Shapes | 10 | 7.26 | 16 | 3.24 | -4.02 |
| Control Software Operation (Mach 3)–Manual Movement | 11 | 7.14 | 18 | 2.96 | -4.18 |
| Machine Code Software Operation (SheetCam)–Basic Setup | 12 | 7.01 | 4 | 6.37 | -0.64 |
| Machine and Software Operation–Drafting Software Operation (V-carve) Drawing Layer Setup | 13 | 6.76 | 10 | 4.44 | -2.32 |
| Plasma Unit Setup–Ventilation System | 14 | 6.71 | 15 | 3.32 | -3.39 |
| Plasma Unit Setup–Air Filtration | 15 | 5.56 | 14 | 3.53 | -2.03 |
| Material Finishing–Material Choice | 16 | 5.15 | 21 | 2.43 | -2.72 |
| CNC Table Setup–Physical Placement | 17 | 4.98 | 13 | 3.68 | -1.30 |
| Plasma Power Unit Setup–Physical Placement | 18 | 4.70 | 11 | 4.39 | -0.31 |
| Safety–Automated Movement Awareness | 19 | 4.61 | 26 | 1.99 | -2.62 |
| Material Finishing–Dross Removal | 20 | 4.60 | 22 | 2.36 | -2.24 |
| CNC Table Setup–Table Leveling | 21 | 4.49 | 17 | 3.22 | -1.27 |
| Safety–Thermal Burn | 22 | 4.32 | 24 | 2.32 | -2.00 |
| Safety–Fume Control | 23 | 4.10 | 25 | 2.22 | -1.88 |
| Safety–Fire Hazard | 24 | 3.19 | 20 | 2.60 | -0.59 |
| Safety–Arc Flash | 25 | 2.67 | 23 | 2.34 | -0.33 |
| Safety–Dust Control | 26 | 1.18 | 19 | 2.77 | +1.59 |

*Note:* The higher the MWDS, the greater the need for professional development.

When focusing on the *Consequence Competence* in the pre-evaluation, participants indicated having the greatest in-service need regarding *drafting software operation (V-carve)–basic part design* (MWDS = 9.49). However, participants also indicated that they had the least need for in-service as related to *safety–thermal burn* (MWDS = 0.55). Concluding the CNCPD, participants indicated to have the greatest in-service need as it related to *control software operation (Mach 3)–troubleshooting* (MWDS = 7.33). Furthermore, the participants had the least in-service need regarding *material finish* – *material choice* (MWDS = 2.04). Overall, participants had the greatest negative change in MWDS in regards to *control software operation (Mach 3)* – *manual movement* (∆ -4.04). Consequently, the post-CNCPD participants indicated the largest positive change in MWDS as *safety–thermal burn* (∆ + 1.89). To further describe the self-perceived *Consequence Competence* professional development needs of participants in regards to the CNCPD, please see Table 6.

Research objective five sought to describe the change in participants' perceived professional development needs related to participants' perceptions of the importance, knowledge, ability to perform, and ability to teach CNCPD competencies, based on pre- and post-test construct scores. Mean, standard deviations, and mode were reported by construct. Based on the summated construct means, at the beginning of the CNCPD, participants perceived the CNCPD competencies: to be of high importance ($M$ = 4.55), had some knowledge ($M$ = 3.34), had some ability to perform ($M$ = 3.27), and had some ability to teach others to perform ($M$ = 3.32) the CNCPD competencies. Concluding the CNCPD, participants determined that they perceived the CNCPD competencies: to be of high importance ($M$ = 4.72), had moderate knowledge ($M$ = 3.92), had moderate ability to perform ($M$ = 3.87), and had moderate ability to teach others to perform ($M$ = 3.85) the CNCPD competencies. Overall, the workshop was successful in increasing participants perceived competence levels across all four constructs – Importance to Teach ($\Delta M$ = +.17), Knowledge to Teach ($\Delta M$ = +.58), Ability to Perform ($\Delta M$ = +.60), and Ability to Teach ($\Delta M$ = +.53). See Table 7 for additional details.

Table 6. Consequence Competence Mean Weighted Discrepancy Scores (MWDS) from Pre and Post CNC Plasma Cutting Technology Workshop Evaluations (n = 19)

| | Pre | | Post | | Δ |
|---|---|---|---|---|---|
| Competencies | Rank | MWDS | Rank | MWDS | MWDS |
| Drafting Software Operation (V-carve)–Basic Part Design | 1 | 9.49 | 5 | 6.18 | -3.31 |
| Machine Code Software Operation (SheetCam)–Tool Setup | 2 | 8.56 | 3 | 6.70 | -1.86 |
| Drafting Software Operation (V-Carve) 2-D Drafting - Connecting Basic Vectors | 3 | 7.83 | 10 | 4.89 | -2.94 |
| Machine Code Software Operation–Part Placement | 4 | 7.70 | 4 | 6.39 | -1.31 |
| Control Software Operation (Mach 3)–Trouble-shooting | 5 | 7.58 | 1 | 7.33 | -0.25 |
| Drafting Software Operation (V-carve) Basic Part Design | 6 | 7.46 | 6 | 5.55 | -1.91 |
| Control Software Operation (Mach 3)–Real time machine adjustment | 7 | 7.45 | 13 | 4.16 | -3.29 |
| Control Software Operation (Mach 3)–Basic machine functions | 8 | 7.38 | 7 | 5.44 | -1.94 |
| Control Software Operation (Mach 3)–Manual Movement | 9 | 6.90 | 18 | 2.86 | -4.04 |
| Drafting Software Operation (V-Carve) 2-D Drafting of Basic Shapes | 10 | 6.78 | 11 | 4.58 | -2.20 |
| Plasma Unit Setup–Ventilation System | 11 | 6.71 | 17 | 3.06 | -3.65 |
| Drafting Software Operation (V-carve) Using Text in a Design | 12 | 6.60 | 8 | 5.29 | -1.31 |
| Machine Code Software Operation (SheetCam)–Basic Setup | 13 | 6.56 | 2 | 6.73 | +0.17 |
| Machine and Software Operation– Drafting Software Operation (V-carve) Drawing Layer Setup | 14 | 6.29 | 9 | 4.93 | -1.36 |
| Material Finishing–Material Choice | 15 | 5.18 | 26 | 2.04 | -3.14 |
| Safety- Automated Movement Awareness | 16 | 4.87 | 24 | 2.24 | -2.63 |
| Plasma Unit Setup–Air Filtration | 17 | 4.83 | 16 | 3.32 | -1.51 |
| CNC Table Setup–Physical Placement | 18 | 4.75 | 14 | 3.98 | -0.77 |
| CNC Table Setup–Table Leveling | 19 | 4.71 | 14 | 3.98 | -0.73 |
| Plasma Power Unit Setup–Physical Placement | 20 | 4.70 | 12 | 4.47 | -0.23 |
| Material Finishing–Dross Removal | 21 | 4.38 | 24 | 2.24 | -2.14 |
| Safety–Fume Control | 22 | 3.86 | 21 | 2.47 | -1.39 |
| Safety–Fire Hazard | 23 | 3.19 | 20 | 2.75 | -0.44 |
| Safety–Arc Flash | 24 | 2.43 | 21 | 2.47 | +0.04 |
| Safety–Dust Control | 25 | 1.18 | 19 | 2.77 | +1.59 |
| Safety–Thermal Burn | 26 | 0.55 | 23 | 2.44 | +1.89 |

*Note:* The higher the MWDS, the greater the need for professional development.

Table 7. Change in Self-Perceived Efficacy Levels of CNC Plasma Cutting Workshop Participants Regarding the Importance to Teach, Knowledge, Ability to Perform, and Ability to Teach CNC Plasma Cutting Technology Competencies to Students (n = 19)

| Construct | Pre | | | | Post | | | | $\Delta M$ |
|---|---|---|---|---|---|---|---|---|---|
| | *n* | *M* | *SD* | *Mo* | *n* | *M* | *SD* | *Mo* | |
| Importance[a] to Teach the Competency ($\alpha$ = .930) | 19 | 4.55 | 0.38 | 5.00 | 19 | 4.72 | 0.32 | 5.00 | +0.17 |
| Knowledge[b] to Teach the Competency ($\alpha$ = .974) | 19 | 3.34 | 0.81 | 2.23[a] | 19 | 3.92 | 0.62 | 4.00 | +0.58 |
| Ability[c] to Perform Competency ($\alpha$ = .975) | 19 | 3.27 | 0.81 | 2.08[a] | 19 | 3.87 | 0.57 | 3.62[a] | +0.60 |
| Ability[c] to Teach Competency ($\alpha$ = .981) | 19 | 3.32 | 0.90 | 3.58[a] | 19 | 3.85 | 0.64 | 3.12[a] | +0.53 |

## Conclusions/Implications/Recommendations

This study utilized an industry, as well as educator, set of unique competencies to evaluate teacher's professional development needs related to CNC plasma arc cutting technology. Likewise, the results of this study allowed for an in-depth description of the professional development needs in regards to CNC plasma arc cutting technology. Thus, the methods of data collection and analysis from this study could provide enhanced methods for the evaluation of STEM-based, technology rich, and industry supported professional development workshops.

Based on the findings of objective one, two, three, and four, researchers sought to describe the change in participants' perceived importance of teaching CNCPD competencies, their knowledge of the CNCPD, and their ability to perform and teach the CNCPD, based on pre- and post-test scores. Researchers concluded for each construct (*importance to teach, knowledge, ability to perform, and ability to teach students to perform*), teachers self-perceived efficacy levels increased after participating in the CNCPD workshop. The construct *Importance to Teach* increased the least by .17 and the construct *Ability to Perform* increased the most by .60. Participants indicated overall, they need professional development in most competencies, across all three-competence areas.

Furthermore, participants indicated a great need for professional development related to the STEM area of computer information systems. Chen (2009) indicated one of the areas STEM education should focus on is computer information systems. Likewise, this study also specifically highlighted engineering principles relating to CNC plasma arc cutting technology. Additionally, participants indicated a need for professional development related to all ($n$ = 5) competencies relating to engineering principles in each of the three competency areas (*Importance, Performance, Consequence*).

Parr, Edwards, and Leising (2006) suggested agricultural mechanics could be used as a context to teach STEM principles and retain the necessary agricultural specific content students need. Furthermore, Roberts and Ball (2009) suggested agricultural educators must align themselves with current industry standards. Moreover, Edwards and Briers (1999), along with Garton and Chung (1996), recommended integrating more Computer Aided Design (CAD) principles into agricultural mechanics. It can be implied though the evaluation of these findings and conclusions that professional development using industry supported context, STEM-based education components, and current agricultural mechanics curriculum could help meet educational objectives suggested by previous researchers (Parr, Edwards, & Leising, 2006; Roberts & Ball, 2009; Garton & Chung, 1996; Edwards & Briers, 1999).

A review of literature has specifically indicated deficiencies in the areas of safe tool operation for agriculture mechanics instructors (Johnson & Schumacher, 1989; Swan 1992, Dyer & Andreason, 1999). Regarding research objective one, the conclusion can be drawn that participants of this study felt the least amount of professional development need related to safety items. Additionally, Texas educational state standards for agricultural mechanics include hand held plasma cutting principles. It can be further implied that regarding the safe operation of the plasma arc cutting unit principles from hand held systems are being applied to CNC plasma arc cutting technology. While participants indicate positive gains in the realm of safety knowledge, researchers would caution against foregoing professional development needs relating to safety due to the unique situations when working with automated equipment.

Research objective five sought to describe the change in participants' perceived professional development needs related to participants' perceptions of the importance, knowledge, ability to perform, and ability to teach CNCPD competencies, based on pre- and post-test construct scores. Participants of this study improved across all four constructs based on mean construct scores for pre and post CNCPD evaluations. Research has noted that the demonstration of concepts to a class can be a challenging teaching style, although arguably, the most widely used style in agricultural education (Adekoya & Olatoye, 2011). Additionally, teacher's confidence can be boosted when a link to industry experts is made (Little, 1993). As such, researchers assert using industry based equipment and expected competencies for professional development not only better serves teachers while performing demonstrations, but using these practices also transfers more real-world concepts into the agricultural mechanics laboratory.

As noted in the findings, the participants improved in all aspects of measured competencies. However, the need for future research still exists. Investigation of incorporating specific STEM areas related to CNC plasma arc cutting technology and the perceived value of linking industry experts with agricultural mechanics instructors should be implemented. Specifically, research should concentrate on those competencies teachers perceive to have the most need in, software manipulation. Additionally, research should include not only perceived levels of ability, but as Saucier, et al., (2014) suggested, also include performance-based indicators.

Teacher educators should also continue to review professional development needs of those in their field. Post-secondary institutions should continue to include plasma arc cutting principles, whether hand or CNC controlled. Furthermore, institutions preparing agriculture educators should include industry based equipment and practices in their curriculum, laboratories, and professional development events. Moreover, educators should strongly consider using performance indicators as well as efficacy indicators when evaluating student knowledge, ability to perform skills, and ability to teach others to perform skills.

One such method for both teachers and students regarding performance indicators could be established certification criteria for complex concepts. One example of existing industry certification program is those related to CAD design software. Further, industry certification exists for many of the STEM concepts and could be adapted for use in the agricultural mechanics curriculum.

## References


Adekoya, Y. M., & Olatoye, R. A. (2011). Effect of demonstration, peer-tutoring, and lecture teaching strategies on senior secondary school students' achievement in an aspect of agricultural science. *Pacific Journal of Science and Technology, 12*(1), 320-332.

Bandura, A. (1986). The explanatory and predictive scope of self-efficacy theory. *Journal of Social & Clinical Psychology, 4*(3), 359-373. doi:10.1521/jscp.1986.4.3.359

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W.H. Freeman.

Blackburn, J. J., Robinson, J. S., & Field, H. (2015). Pre-service agriculture teachers' perceived level of readiness in an agricultural mechanics course. *Journal of Agricultural Education, 56*(1), 172-187. doi:10.5032/jae.2015.01172

Borich, G. D. (1980). A needs assessment model for conducting follow-up studies. *The Journal of Teacher Education, 31*(3), 39-42. doi:10.1177/002248718003100310

Borich, G. D., & Fenton, K. S. (1977). *The appraisal of teaching: Concepts and process.* Addison Wesley Publishing Company.

Burris, S., Robinson, J. S., & Terry, R. (2005). Preparation of pre-service teachers in agricultural mechanics. *Journal of Agricultural Education, 46*(3), 23-34. doi:10.5032.jae.2005.03023

Cantwell, J. (1999). Innovation as the principle source of growth in the global economy. In D. Archibugi, J. Howells, & J. Michie (Eds.), *Innovation policy in a global economy* (pp. 229-235). Cambridge, UK: Cambridge University Press.

Chen, X. (2009). Students who study science, technology, engineering, and mathematics (STEM) in postsecondary education. National Center for Education Statistics - U.S. Department of Education. NCES 20019-161.

Chumbley, S. B., Gill, B. E., & Chesher, L. (2013). Laboratory safety practices of New Mexico agricultural science teachers. Paper presented at the 2013 Western Region AAAE Research Conference, Lubbock, Texas.

Conroy, C., & Kelsey, K. (2000). Teacher education response to reinventing agricultural education for the year 2020: use of concept mapping to plan for change. *Journal of Agricultural Education, 41*(1), 8-17. doi: 10.5032/jae.0222.01008

Croom, B. (2008). The development of the integrated three-component model of agricultural education. *Journal of Agricultural Education, 49*(1), 110-120. doi:10.5032/jae.2008.01110

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

Dyer, J. E., & Andreasen, R. J. (1999). Safety issues in agricultural education laboratories: A synthesis of research. *Journal of Agricultural Education, 40*(2), 46-54. doi:10.5032/jae.1999.02046

Edwards, M. C., & Briers, G. E. (1999). Assessing the inservice needs of entry-phase agriculture teachers in Texas: A discrepancy model versus direct assessment. *Journal of Agricultural Education, 40*(3), 40-49. doi:10.5032/jae.1999.03040

Fleischman, H. L., Hopstock, P. J., Pelczar, M. P., & Shelley, B. E. (2010). Highlights from PISA 2009: Performance of US 15-Year-Old Students in Reading, Mathematics, and Science Literacy in an

International Context. NCES 2011-004. National Center for Education Statistics - U.S. Department of Education.

Garton, B. L., & Robinson, J. S. (2006). Career paths, job satisfaction and employability skills of agricultural education graduates. *NACTA Journal, 50*(4), 31-36.

Garton, B. L., & Chung, N. (1996). The inservice needs of beginning teachers of agriculture as perceived by beginning teachers, teacher educators, and state supervisors. *Journal of Agricultural Education, 37*(3), 52-58. doi:10.5032/jae.1996.03052

Huberman, A. M. (1993). *The Lives of Teachers*. Columbia University: Teachers College Press.

Hubert, D., & Leising, J. (2000). An assessment of agricultural mechanics courses requirements in agricultural teacher education. *Journal of Southern Agricultural Education Research, 50*(1), 24-31.

Johnson, D. M., & Schumacher, L. G. (1989). Agricultural mechanics specialists identification and evaluation of agricultural mechanics laboratory management competencies: A modified delphi approach. *Journal of Agricultural Education, 30*(3), 23-28. doi: 10.5032/jae.1989.03023

Kessels, J. W. & Poell, R. F. (2004). Andragogy and social capital theory: The implications for human resource development. *Advances in Developing Human Resources, 6*(146). doi:10.1177/1523422304263326

Knowles, M.S. (1983). Adults are not grown-up children as learners. *Community Services Catalyst, 13*(4), 4-8.

Knowles, M. S., Holton III, E. F., & Swanson, R. A. (2005). *The adult learner*. San Diego, CA. Elsevier.

Lambeth, J.M., Elliot, J., & Joerger, R. (2008). Research report: The national career and technical education research agenda. Techniques, October, 52-55.

Langley, G. C., & Kitchel, T. (2013). Agricultural mechanics instructors' perception of the health beliefs in their laboratory. Paper presented at the Western Region American Association for Agricultural Education Research Conference, Lubbock, Texas.

Leake, A. H. (1915). *The means and methods of agricultural education*. Boston, MA & New York, NY: The Riverside Press Cambridge.

Little, J. W. (1993). Teachers' professional development in a climate of educational reform. *Educational Evaluation and Policy Analysis, 15*(2), 129-151. doi: 10.3102/01623737015002129

McKim, B. R. (2013). Assessing knowledge, performance, and consequence competence with the Borich needs assessment model. College Station, TX: Texas A&M University.

McKim, B. R., & Saucier, P. R. (2011). Agricultural mechanics laboratory professional development needs of Wyoming secondary agriculture teachers. Journal of Agricultural Education, 52(3), 75-86. doi: 10.5032/jae.2011.03075

Newman, M. E. (2017) Capital A, Capital E – Ripples in the agricultural education pool. *Journal of Agricultural Education*, *58*(1), 1-13. doi:10.5032/jae.2017.01001

Parr, B. A., Edwards, M. C., & Leising, J. G. (2006). Effects of math-enhanced curriculum and instructional approach on the mathematics achievement of agricultural power and technology students: An experimental study. *Journal of Agricultural Education, 47*(3), 81-93. doi:10.5032/jae.2006.03081

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

Roberts, G., & Ball, A. (2009). Secondary agricultural science as content and context for teaching. *Journal of Agricultural Education, 50*(1), 81-91. doi: 10.5032/jae.2009.01081

Roberts, T.G., Harder, A., & Brashears, M. T. (Eds.). (2016). American Association for Agricultural Education national research agenda: 2016-2020. Gainsville, FL: Department of Agricultural Education and Communication.

Saucier, P. R., & McKim, B. R. (2011). Assessing the learning needs of student teachers in Texas regarding management of the agricultural mechanics laboratory: Implications for the professional development of early career teachers in agricultural education. *Journal of Agricultural Education, 52*(4), 24-43. doi:10.5032/jae.2011.04024

Saucier, P. R., McKim, B. R., Muller, J. E., & Kingman, D. M. (2014). Assessing performance and consequence competence in a technology-based professional development for agricultural science teachers: An evaluation of the Lincoln Electric welding technology workshop. *Career and Technical Education Research, 39*(2), 103-108. doi:10.5328/cter39.2.103

Saucier, P. R., Terry, Jr., R., & Schumacher, L. G. (2009, February). Laboratory management professional development needs of Missouri agriculture educators. Paper presented at the 2009 Proceedings of the Southern Region of the American Association for Agricultural Education Conference, Atlanta, GA.

Spector, P. E. (1992). *Summated rating scale construction: An introduction*. Newbury Park, CA: Sage Publications, Inc.

Sorenson, T. J., Lambert, M. D., & McKim, A. J. (2014). Examining Oregon agriculture teachers professional development needs by career phase. *Journal of Agricultural Education, 55*(5), 140-154. doi: 10.5032/jae.2014.05140

Stubbs, E. A., & Myers, B. E. (2016). Part of what we do: Teacher perceptions of STEM integration. *Journal of Agricultural Education, 57*(3), 87-100. doi: 10.5032/jae.2016.03087

Swan, M. K. (1992). An Analysis of agricultural mechanics safety practices in agricultural science laboratories. Paper presented at the American Vocational Association, St. Louis, MO.