ISSN 2327-0160 (Online)
Volume 12. Number 1.

Determining the Teaching Resources Needed for an Ideal Post-Secondary Applied STEM (Agricultural Mechanics) Learning Laboratory: A Delphi Approach

J. Chris Haynes
Tarleton State University
chaynes@tarleton.edu

Ryan Anderson
Texas State University
r_a461@txstate.edu

A. Preston Byrd
Abraham Baldwin Agricultural College
alex.byrd@abac.edu

OP McCubbins
Mississippi State University
op.mccubbins@msstate.edu

Abstract
Agricultural Education provides an avenue to integrate and emphasize STEM-based concepts through a contextualized approach, which has been seen as a possible solution to increase student competence in STEM-based areas. The contextualized teaching and learning theory and the Curriculum for Agricultural Science Education (CASE) curriculum-learning model undergirds this research. Contextualized teaching and learning can be defined as applying received information to real-life situations and experiences in various contextual learning environments. With a new curriculum, adequate tools and equipment are vital in preparing students for the workforce. However, the issue of inadequate teaching materials has been prevalent within the entire educational system, and such inadequacies are detrimental to the ability of the students to become proficient in agricultural mechanics. The purpose of this Delphi study is to identify the perceptions of an "expert group" of educators on a list of equipment and supplies that would be included in an ideal Post-Secondary Applied STEM Learning Laboratory targeted at helping better prepare pre-service agriculture educators in content integration prior to entering the secondary education classroom. The data collected in the first round from the thirty-four participants who responded resulted in a 68% response rate. A total of 443 individual tools were identified within the 23 content areas listed in the CASE Agricultural Power and Technology (APT) curriculum. The overwhelming majority of tools the panel of experts identified would be what you would find in a standard agricultural mechanics laboratory. Therefore, the costs associated with transitioning from a traditional agricultural mechanics laboratory to a Post-Secondary Applied STEM Learning Laboratory should be minimal.

Introduction
Numerous reports over the last two decades have identified that progress in science education in the United States has waned (National Center for Education Statistics, 2005). As a result of this decline, attempts at reformative measures in science student achievement have been insignificant (Johnson, 2012). Recently, in response to the lackluster academic performance of United States

ISSN 2327-0160 (Online)
Volume 12. Number 1.

students and the significant decline behind other nations in science, technology, engineering, and mathematics (STEM) disciplines, and the systematic failure of the educational system in preparing future innovative workers, resulted in political intervention by the Obama administration (Barack Obama and Joe Biden's Plan for Lifetime Success Through Education, 2009). According to the National Science Board (2010) report, ". . . the quality of K-12 STEM education has been identified as a key factor in the performance of U.S. students, decline in STEM pipeline, and position of the United States globally" (Johnson, 2012, p. 46).

Agricultural Education has been identified as a potential solution to the lack of student science and mathematics competency (National Research Council [NRC], 1996), as the integration and emphasis of STEM-based concepts through a contextualized approach (Roberts & Ball, 2009) is ideally suited to the instruction of science, mathematics, and other STEM-related areas (Anderson & Swafford, 2021; Balschweid, 2002; Thompson & Balschweid, 2000). Dewey (1938) stated that the blending of academic content in a contextually heavy-based curriculum has vast potential for the transfer of knowledge and life skills, thereby increasing the potential for academic success. As a contextual framework, agriculture has been acknowledged as ideally suited for the integration, retention, and transference of academic knowledge (Roberts & Ball, 2009).

Teachers need assistance in the transformation of teacher educator programs to one that would align future educators with the pedagogical tools they need to effectively integrate "content" and STEM education (Johnson, 2013; Stohlmann et al., 2012) through applied practice and project-based learning. Recently, project-based learning has been seen as a real-world way to foster scientific inquiry through self-directed student activity (Barak & Dori, 2005). Preservice teachers who are provided opportunities for content-specific pedagogical instruction experience an increased balance of teacher efficacy and confidence (Robinson et al., 2010; Tschannen-Moran & Woolfolk Hoy, 2002), increasing the probability of meeting national content standards (McCubbins et al., 2016).

The contextualized teaching and learning theory and the Curriculum for Agricultural Science Education (CASE) curriculum-learning model undergirds this research. Contextualized teaching and learning can be defined as applying received information to real-life situations and experiences in various contextual learning environments (ERIC Clearinghouse on Adult, Career, and Vocational Education & ERIC Clearinghouse on Teaching and Teacher Education, 1998). Curry et al. (2012) maintained that the contextualized teaching and learning process be characterized as one that ". . . is problem-based; occurs in multiple contexts (schools, homes, worksites, communities); fosters self-regulated learning; anchors teaching and learning in students' diverse life contexts; employs authentic assessment; and uses interdependent learning groups" (p. 59).

The Curriculum for Agricultural Science Education (CASE) is designed to enhance the rigor and relevance of agriculture, food, and natural resources subject matter. The CASE curriculum uses scientific inquiry as the foundation to enhance science and mathematics understanding by utilizing activities, projects, and problem-based instructional strategies (CASE, 2014). The Agricultural Power and Technology (APT) course outline has been developed for the CASE curriculum. According to McCubbins, et al. (2016), adequate tools and equipment are vital in preparing students for the workforce. However, the issue of inadequate teaching materials has been prevalent within the entire educational system, and such inadequacies are detrimental to the ability of the students to become proficient in agricultural mechanics (Anderson & Anderson, 2018; McCubbins et al., 2017).

Insufficient teaching materials and supplies create impediments for both teachers and students that can lead to failure to meet teaching standards, competency exams, and being less competitive in getting into the workforce (McCubbins et al., 2016; Oakes & Saunders, 2002). McCubbins et al. (2017) found that teachers felt more competent to teach agricultural mechanics topics if they felt they had adequate materials and tools in their laboratory. Since agricultural mechanics is a sought-after class by secondary students because of the hands-on nature of the class, teachers must have the necessary tools and equipment to be successful in preparing laboratory exercises that replicate real-life situations (Agnew & Shinn, 1987; Blackburn & Kelsey, 2012; Byrd et al., 2015; Sutphin, 1984).

Theoretical and Conceptual Framework

Human capital theory was the guiding theoretical framework for this study. Haynes et al. (2014) state that humans are like other commodities and are capable of being developed so that they can be more beneficial economically and socially. One important method utilized to develop one's human capital is through the use of education (Olaniyan & Okemakinde, 2008; Psacharopoulos & Woodhall, 1997; Sakamota & Powers, 1995; Schultz, 1971). Previous researchers have stated that one area that is emphasized by human capital theory is how education increases the cognitive stock of humans to make them more economically beneficial (Haynes et al., 2014; Olaniyan & Okemakinde, 2008; Schultz 1971). The increase of cognitive stock is the primary goal of all post-secondary teacher preparation programs, so that the human capital that goes into teaching is competent in their subject area but can also impact their students, school, and community (Beaulieu & Mulkey, 1995; Haynes et al., 2014).

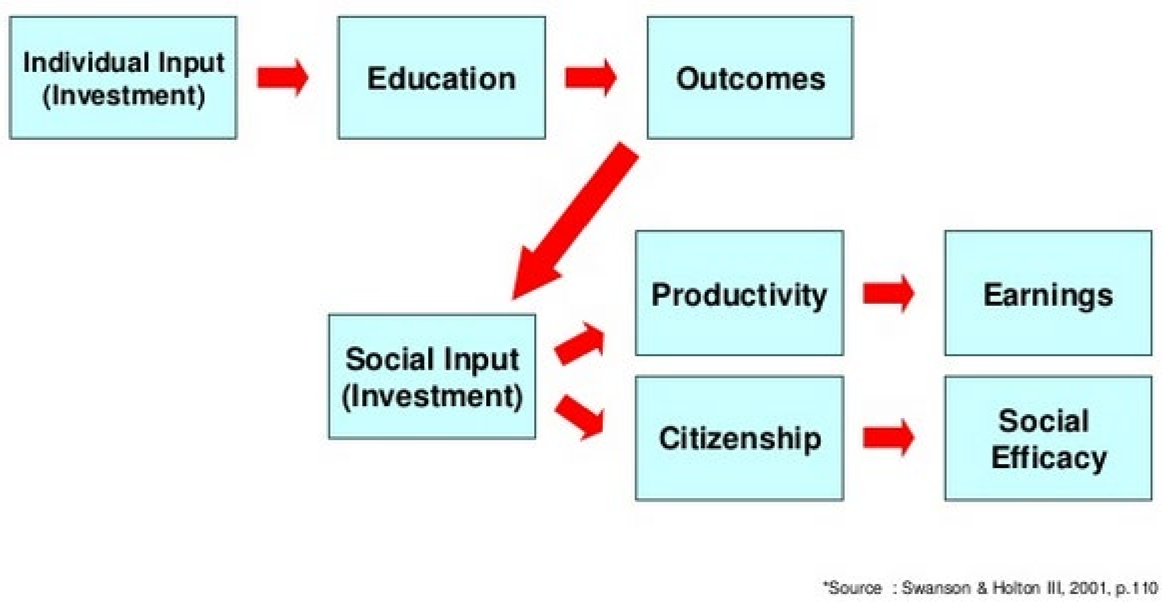

Figure 1. Model of Human Capital Theory. Adapted from "Foundations of Human Resource Development" by R. A. Swanson, and E. F. Holton, 2009. San Francisco, Calif: Berrett-Koehler Publishers.

In agricultural education, the functioning and sustainability of the profession are dependent on the human capital stock that is developed within post-secondary agricultural education teacher preparation programs. Investment in human capital is based on three beliefs, according to Babalola (2003), which states that previously gained knowledge of past generations must be given to the new generation. The second belief focuses on how to create new ideas and products using the existing knowledge given to them. Lastly, creative approaches are encouraged to develop entirely new ideas and products. One area that has become prominent in education is the incorporation of STEM concepts in agricultural education curricula (Doerfort, 2011). In the past decade, through the creative approaches of human capital, the CASE curriculum was created to help advance the efforts of integrating STEM into agricultural education (CASE, 2014).

Purpose and Objectives

The purpose of this Delphi study is to identify the perceptions of an "expert group" of educators on a list of equipment and supplies that would be included in an ideal Post-Secondary Applied STEM Learning Laboratory targeted at helping better prepare pre-service agriculture educators in content integration prior to entering the secondary education classroom. The following objectives guided this study:

1. Determine the demographics of the panel of experts serving as the population for this study.
2. Determine by consensus a list of equipment and supplies that would be included in an ideal Post-Secondary Applied STEM Learning Laboratory

Methodology

The purpose of this Delphi study is to identify the perceptions of an "expert group" of educators on a list of equipment and supplies that would be included in an ideal Post-Secondary Applied STEM Learning Laboratory targeted at helping better prepare pre-service agriculture educators in content integration prior to entering the secondary education classroom. A three-round Delphi method was designed to serve as a research tool to gain insight from an "expert" group on an open-ended question(s), where responses are distilled, achieving a reliable consensus to confirm or contradict the study (Delp et al., 1977). Hasson et al. (2000) indicated that the Delphi approach is a "group facilitation technique, which is an iterative multistage process, designed to transform opinion into group consensus" (p. 1008). The Delphi method is a valuable tool to investigate problems where a lack of information is available regarding a given issue (Skulmoski et al., 2007).

Delp et al. (1977) described the Delphi method as a group process by which a panel of experts is assembled to provide informed judgment toward consensus on a specific topic. A three-member advisory panel consisting of faculty from two land grant university systems and one state university from each region (North Central, Southern, & Western) of the American Association for Agricultural Education (AAAE) nominated members of the panel of experts. The advisory panel was provided with a set of criteria to guide the establishment of the panel of experts. The list of criteria included: (1) post-secondary faculty and staff that teach a diverse set of agricultural mechanics courses and have secondary agricultural education experience; (2) post-secondary agricultural education department chairs that have experience teaching agricultural mechanics and worked closely with the agricultural mechanics curriculum offered at their institution; (3) doctoral students in agricultural education that have a graduate teaching and/or research assistantship related to agricultural mechanics and had prior secondary agricultural education experience; and (4) current school-based agricultural education teachers who are considered experts in agricultural mechanics within their respective states.

The advisory panel identified a panel of experts (N=50) that were comprised of university faculty and staff (n=15) that teach agricultural mechanics, agricultural education department chairs (n=5), agricultural education Ph.D. graduate students (n=7), and current secondary agricultural education teachers (n=23) who teach agricultural mechanics/power systems, as recommended by association leadership in the National Association for Agricultural Education (NAAE) and had served as reviewers for a recent agricultural mechanics textbook. At least one member from each of the four groups above represented all three regions (North Central, Southern, & Western) of the American Association for Agricultural Education (AAAE). The demographics of the 13 experts who have completed all three rounds of the Delphi methods are included in the appendix.

The three-round Delphi technique used in this research study contributed to establishing content and concurrent validity (Sharkey & Sharples, 2001). Habibi et al., (2014) suggested that content validity can be established in a Delphi study by carefully selecting participants who have an interest and a depth of knowledge in the topic. Using the selection criteria for our panel of experts, we were able to identify participants who had a strong interest in agricultural mechanics and, more specifically, the equipment and supplies necessary to teach in an applied STEM learning laboratory. Furthermore, Hasson and Keeney (2011) indicated that successive rounds of the Delphi process allow the experts to reach a level of agreement on the responses put forth by the group, leading to establishing concurrent validity. In a Delphi study, when a group of selected experts exceeds 13, the reliability of the study is greater than .80 (Dalkey, 1969). However, it should be noted that establishing reliability in Delphi studies is suspect and serves as a limitation (Hainline & Wells, 2019). Therefore, caution should be exercised when generalizing the findings of this study.

Upon the agreement of the panelists to participate, this study employed three separate rounds of questionnaires and was initiated through an email detailing the process and anticipated timeline. The study was conducted electronically via Qualtrics, an online data collection instrument. Each round was closed after 21 days, and data collection was closed after 63 days. Following the initial distribution of questionnaires in each round, two follow-up reminder emails were sent to the participants in seven-day increments, following the recommendations from Yun and Trumbo (2000). The first round of the study used an open-ended questionnaire that included eight questions focusing on equipment and supplies needed for the varying topics derived from the CASE APT curriculum. The CASE curriculum is aligned with the Agricultural, Food, and Natural Resources Career Cluster Content Standards (The Council, 2024), and the National Science Education Standards (NRC, 1996). At the conclusion of this round, a total of 443 individual items were identified as equipment and supplies needed within the eight content areas listed in the CASE APT curriculum.

The second-round questionnaire was sent electronically to only those who had participated in the first round. In the second questionnaire, panelists were asked to review each item and indicate their level of agreement on the importance of each item that would be included in an ideal Post-Secondary Applied STEM Learning Laboratory. The panelists were asked to rate the 443 items identified in round one using a five-point Likert-type scale (1 = Strongly Disagree, 2 = Disagree, 3 = Uncertain, 4 = Agree, 5 = Strongly Agree). The second-round instrument also included an open-ended question that asked the panel members to include any other tools or equipment that should be considered. Items that received a score of four (Agree) or five (Strongly Agree) from at least 80% of the experts were considered to have reached consensus. No additional recommendations from the panel of experts were included in the open-ended question.

The third questionnaire sought to further determine consensus. The third questionnaire was sent to only those who had participated in the second round. Panel members were asked to provide a dichotomous indication as to whether they agreed or disagreed with each of the 413 tools and equipment that were critical in incorporating the CASE APT curriculum. The participants were also asked to provide comments if they could not agree with the summary findings. Consensus was reached on 437 items, with no suggested revisions, and thus, data collection ceased.

The Statistical Package for Social Sciences (SPSS©) Version 29 software was used to analyze the data collected in this study. The data gathered from the eight open-ended questions were aligned by the content areas listed in the CASE APT curriculum and were analyzed by organizing the expert's responses to each area. Descriptive statistics were computed for Likert-type items contained in the two subsequent rounds of the Delphi process.

Results

The objective of this study sought to identify a list of equipment and supplies that would be included in an ideal Post-Secondary Applied STEM Learning Laboratory. The Delphi technique of obtaining group consensus was used to accomplish this objective. The first round of the study used a questionnaire with an open-ended question to facilitate the generation of a wide array of response categories. The questions that were used coincided with the CASE APT curriculum content specific area list and are detailed in Table 1.

Table 1

CASE Ag Power and Technology Curriculum Content Areas

Resources needed in an Applied STEM Lab to teach concepts in the content area of:
1. Components of Agricultural Power and Technology, including two topics: The first being Mechanical World.
2. Components of Agricultural Power and Technology, including two topics: The second being Mechanical Basics.
3. Safety and Tool Use, including three topics: The first being Safety in the shop setting.
4. Safety and Tool Use, including three topics: The second being Machine and tool operations safety.
5. Safety and Tool Use, including three topics: The third being Measurement in agriculture.
6. Building and Design Materials used in Agriculture, including four topics: The first being Structural materials in Agriculture
7. Building and Design Materials used in Agriculture, including four topics: The second being Fluids in Agriculture

ISSN 2327-0160 (Online)
Volume 12. Number 1.

8. Building and Design Materials used in Agriculture, including four topics: The third being Earthen materials in agriculture
9. Building and Design Materials used in Agriculture, including four topics: The fourth being Fabricating materials
10. Agricultural Energy and Power, including four topics: The first being Heat
11. Agricultural Energy and Power, including four topics: The second being Electrical
12. Agricultural Energy and Power, including four topics: The third being Fluid
13. Agricultural Energy and Power, including four topics: The fourth being Renewable Energy
14. Machines, including three topics: The first being Simple Machines
15. Machines, including three topics: The second being Machine Systems
16. Machines, including three topics: The third being Transmission of Power
17. Machinery Management, including three topics: The first being Machine Performance and Efficiency
18. Machinery Management, including three topics: The second being Calibration and Monitoring of Power
19. Machinery Management, including three topics: The third being Technical Reading and Problem Solving
20. Engineering, including three topics: The first being Design Process
21. Engineering, including three topics: The second being Construction Processes
22. Engineering, including three topics: The third being Testing Processes
23. Technologies that enhance tools and equipment

Note: A list of all tools is listed in the appendix

Round One

Data collection in round one consisted of responses generated through the open-ended questions seeking to determine what resources are needed in an applied STEM laboratory to teach contextually specific concepts in the different content areas of agricultural power and technology systems. The data collected in the first round from the thirty-four participants who responded resulted in a 68% response rate. A total of 443 individual tools were identified within the 23 content areas listed in the CASE APT curriculum. Table 2 contains the 25 tools and equipment most frequently identified in round one.

Table 2

Delphi Round 1: Tools and Equipment Needed for an Ideal STEM laboratory (n = 34)

	Tools and Equipment Identified
1.	Safety Data Sheets, Adequate square footage of laboratory space per student . . .
2.	Ag Power (small gas engines, tools), C2H2 - O2 applications, CNC plasma cam . . .
3.	Safety materials (goggles, hearing protection, fire extinguishers, fire blanket.) . . .
4.	Clean-up/maintenance guidelines, Computers, Consumables, Gloves, Hand tools . . .
5.	Modern machinery problems, Combination square, Dial calipers, Dial gauges . . .
6.	Auto level, Band saw, building materials, CAD for design, Compound miter saw . . .
7.	Cylinders, Fluid, Fluid trainers, Fuels, Hoses, Hydraulic systems, Hydraulic trainers . . .
8.	Auto and laser level, EDM (Electronic Distance Measuring), Flags, Levels . . .
9.	Arc Welders, Band saw, Concrete tools, Metal tools, Wood tools, CAD equipment . . .
10.	Electric welders, IR cameras to detect heat loss, Oxy-fuel setups, Propane torch . . .
11.	Electrical tools and fixtures, teaching aids, Circuit breakers, Electric motor controls . . .
12.	Fluid power equipment, Hydraulic power equipment, Hydraulic trainer . . .
13.	Electrical motor (12v), Generation and storage of chemical electricity . . .
14.	Items displaying mechanical advantage, Gears to attach to small motors . . .
15.	Activities that illustrate how electrical and hydraulic energy is harnessed to do work . . .

16. Wiring principles, Hydraulics lab, Teaching aids covering bearings, belts, and gears . . .
17. Engine performance testing equipment . . .
18. Aids to monitor power and how conditions affect power, Tools for calibration . . .
19. Activities requiring reading and problem solving, Problems using real-world items . . .
20. Basic plan reading, Computer-aided design programs . . .
21. Real projects requiring management and oversight, Plans, Reference material . . .
22. Performance testing equipment, Reference material . . .
23. Activities illustrating use of tools to perform functions, bring concepts to reality, and to address needs . . .

Round Two

Thirteen of the 34 individuals responded in round two, for a 38% response rate. In this round, respondents were asked to rate the 423 tools and equipment identified in round one on a Likert-type scale (1 = Strongly disagree, 2 = Disagree, 3 = Uncertain, 4 = Agree, 5 = Strongly Agree), and to add any critical tools and equipment not included on the list. Results of responses for round two include 107 tools and equipment that the panel strongly agreed with, 306 tools and equipment that the panelists agreed with, ten tools that the panelists were uncertain about, and the panelists did not identify any tools or equipment that they disagreed or strongly disagreed with. Displayed in Table 3 are the top-ranked tools and equipment for *Components of Agricultural Power and Technology* that the panelists strongly agreed (M = 4.50 – 5.00) and agreed (M = 3.50 – 4.49) with over and above seven of the tools and equipment that they were uncertain (M = 2.50 – 3.49) about (Table 3).

Table 3

Delphi Round Two: Level of Agreement with Ranked Tools and Equipment (n = 13)

	Tools and Equipment	*M*	*SD*
Q1	**Components of Agricultural Power and Technology, which includes two topics: The first being Mechanical World**		
	Safety Training	4.54	1.20
	PPE; apparel, glasses, face-shield, washbasin, etc.	4.69	1.11
Q2	**Components of Agricultural Power and Technology, which includes two topics: The second being mechanical basics**		
	Digital Multi-Meter	3.17	0.94
	Basic content specific hand and power Tools	3.33	1.44
	Laser cutter; Wood lathe	3.42	1.08

1.00 – 1.49 = Strongly Disagree, 1.50 – 2.49 = Disagree, 2.50 – 3.49 = Uncertain, 3.50 – 4.49 = Agree, 4.50 – 5.00 = Strongly Agree.

Ranked tools and equipment that reached a level of strong agreement by those surveyed included Personal Protective Equipment (PPE) to include apparel, glasses, face-shields, washbasins, etc. (M = 4.69) and safety training (M = 4.54). Those ranked tools and equipment the panel of experts were uncertain about included the use of a digital multi-meter (M = 3.17) in the Ideal STEM enhanced laboratory.

Regarding *Safety and Tool Use* (Table 4), it was determined that PPE was considered essential for inclusion in the laboratory setting (M = 5.00) for two of the topic areas, *Safety in the Shop*

Setting, and *Machine and Tool Operations Safety,* along with the use of properly maintained equipment with all safety features (M = 4.91) as strongly agreed upon in the second content area of *Machine and Tool Operations Safety.* However, the panel of experts could not reach agreement with the use of instructional DVDs to support STEM laboratory safety in the topics of *Safety in the Shop Setting* (M = 3.27) or *Measurement in Agriculture* (M = 3.18) (Table 4).

Table 4

Delphi Round Two: Level of Agreement with Ranked Tools and Equipment (n = 13)

	Tools and Equipment	***M***	***SD***
Q3	**Safety and Tool Use, which includes three topics: The first being Safety in the shop setting**		
	Teaching aids (computers, video, etc.) Tool specific safety rules	4.55	0.52
	Lab management guidelines	4.55	0.69
	Safety protocol	4.55	1.21
	Power tools; Safety colors and zones; State/National shop safety guidelines	4.64	0.50
	Current industry safety curriculum; Permanent safety features, (ventilation, etc.); Wash Basins	4.73	0.47
	Safety exams; shields; ventilation systems	4.82	0.40
	Safety Equipment (PPE, fire extinguishers, blanket, fire alarm); Safety rules/tests; Welding helmets	4.91	0.30
	PPE; Safety glasses	5.00	0.00
	Instructional DVD	3.27	1.42
Q4	**Safety and Tool Use, which includes three topics: The second being Machine and tool operations safety**		
	Larger stationary equipment (drill press, metal breaks, etc.)	4.55	0.82
	Curriculum; Inclusion of modern and current machine and power tools used in industry; Teaching aids (computers, video abilities, etc.)	4.55	0.52
	Safety Contracts	4.55	0.69
	Clean-up/maintenance guidelines; Instruction in hand tools; machine and power tools; Specific application safety items	4.64	0.50
	Hand and power tools to demonstrate safe operating procedures; Safety exams; Tool guards, specific safety, and area markers	4.73	0.47
	Safety rules/test	4.82	0.40
	Properly maintained equipment with all safety features; Welding helmets	4.91	0.30
	PPE (Personal Protective Equipment)	5.00	0.00
Q5	**Safety and Tool Use, which includes three topics: The third being measurement in agriculture**		
	Dial calipers and gauges; Rulers, yardsticks, steel tape, squares, torque wrenches, and traditional measuring tools	4.55	0.52
	Basic tools of measurement including dimensions, weight, volume, etc.; Curriculum; Feeler gauges; Framing square; Hand and power tools; Inside/outside calipers; Micrometers; Tape measures (log tape, fiberglass tape, standard lumber tape, survey instruments)	4.64	0.50
	Levels; Precision measuring equipment (surveying equipment, micrometers, calipers, etc.)	4.73	0.47
	Instructional DVD	3.18	1.08

1.00 – 1.49 = Strongly Disagree, 1.50 – 2.49 = Disagree, 2.50 – 3.49 = Uncertain, 3.50 – 4.49 = Agree, 4.50 – 5.00 = Strongly Agree.

It was determined by the panel of experts that Personal Protective Equipment (PPE) (M = 5.00) was again strongly agreed upon as a necessary component of a STEM enhanced laboratory learning environment in the content area, *Building and Designing Materials Used in Agriculture* under the heading of fabricating materials. However, those surveyed found difficulty coming to an agreement with regards to the use of a smartboard (M = 3.45) in the topic area *Earthen Materials in Agriculture* (Table 5).

Table 5

Delphi Round Two: Level of Agreement with Ranked Tools and Equipment (n = 13)

	Tools and Equipment	***M***	***SD***
Q6	**Building and Design Materials used in Agriculture, which includes four topics: The first being Structural materials in Agriculture**		
	Cross/rip saw; Fasteners; Framing squares; Portable circular saw; Squares (rafter, tri, tri-miter, combination); Table saw; Tables with clamps	4.55	0.52
Q8	**Building and Design Materials used in Agriculture, which includes four topics: The third being Earthen materials in agriculture**		
	Smartboard	3.45	1.29
Q9	**Building and Design Materials used in Agriculture, which includes four topics: The fourth being Fabricating materials**		
	Band saw; Metal construction materials; Wood storage racks	4.55	0.69
	Basic metal tools; Basic wood tools; Compound miter saw; Metal cutting band saw; MIG Welders; Oxy-fuel cutting equipment; Plasma cutting equipment; Portable circular saw; Table saw; Welding rods	4.64	0.50
	Arc Welders; Pedestal grinder; Portable grinder	4.73	0.47
	Personal Protective Equipment	5.00	0.00

1.00 – 1.49 = Strongly Disagree, 1.50 – 2.49 = Disagree, 2.50 – 3.49 = Uncertain, 3.50 – 4.49 = Agree, 4.50 – 5.00 = Strongly Agree.

In table 6, four topic areas exist under *Agricultural Energy and Power,* with those surveyed finding the highest level of agreement in the use of Multimeters (M = 4.82), followed by the use of Wiring Boards (M = 4.73) under the *Electrical* topic. There was not a level of agreement reached with regards to the inclusion of student learning in small engines (M = 3.36).

Table 6

Delphi Round Two: Level of Agreement with Ranked Tools and Equipment (n = 13)

	Tools and Equipment	***M***	***SD***
Q10	**Agricultural Energy and Power, which includes four topics: The first being Heat**		
	Fuel and energy storage cabinet,	4.55	0.69
	Oxy-fuel setups	4.55	0.52
	Electric welders	4.64	0.50
Q11	**Agricultural Energy and Power, which includes four topics: The second being Electrical**		
	Electrical meters; Power transfer safety device; Principles of AC electrical power; Principles of DC electrical power; Screwdrivers; Wire nuts	4.55	0.52

All electrical tools and fixtures; Basic electrical teaching aids; Circuit breakers; Junction boxes; Light fixtures; Outlets; Switches; Wire	4.64	0.50
Wiring boards	4.73	0.47
Multimeters	4.82	0.40
Small engines	3.36	1.29

1.00 – 1.49 = Strongly Disagree, 1.50 – 2.49 = Disagree, 2.50 – 3.49 = Uncertain, 3.50 – 4.49 = Agree, 4.50 – 5.00 = Strongly Agree.

Round Three

In round three, respondents were provided with both their own individual ratings and those of the group from round two. Panel members were asked to provide a dichotomous indication of whether they agreed or disagreed with each of the 413 tools and equipment as critical for including in the CASE APT curriculum. The participants were also asked to provide comments if they could not agree with the summary findings. All thirteen of the panel members who responded in round two participated in this round, for a 100% response rate. Table 7 contains summary data for this round and includes those tools and equipment that reached a consensus level of 80% or higher by the panel of experts.

Table 7

Delphi Round Three: Tools & Equipment Needed that Reached Consensus for the CASE Agricultural Power and Technology Curriculum (n = 13)

Tools & Equipment	
Q2	Adequate lab space per student/worker; Appropriate lighting; Building supplies . . .
Q4	Building supplies; CNC Plasma cam; Computer-driven technology machines (Plasma, laser cutter, CO2 engraver, Wood shaper); Concrete Tools . . .
Q6	Safety tests; Gloves; Handouts; Hazard Identification and reduction . . .
Q8	Consumables; Hand tools; Tool area guards and markers; Safe operation videos . . .
Q10	Basic measurement tools (Dimensions, weight, volume, etc.); Combination square; Curriculum; Hand/Power tools; Survey equipment . . .
Q12	Wood clamps for safety purposes; Woodworking (Building floors, wall, roofs, etc.) . . .
Q14	Fluid trainers; Syringes, tubing, small lumber; associated tools; Pneumatics
Q16	Auto and laser level; Computer; EDM (Electronic distance measuring)
Q18	Composite construction materials; Fasteners; Jointer; Planer; Pneumatic nail gun; Vises
Q20	Learning activities (Concepts and measurements of energy); Ovens; Small gas engines
Q22	Electrical tools, fixtures; Electric motor controls; Electrical pliers; Motion controls; . . .
Q25	Tanks; Windmills; Alternative energy items
Q27	Items that display mechanical advantage; Hand tools; Small 12V Machine Motors Fasteners; Handouts
Q29	Hydraulics Lab; Activities to illustrate how electrical/hydraulic energy is harnessed to do work; Teaching aids
Q31	Basic wiring principles; Handouts; Hydraulics lab; Teaching aids covering belts, gears
Q35	Basic tools; Reading, problem-solving learning activities; Problems involving Realia
Q37	Basic plan reading
Q38	Management and oversight projects; videos

* Tools and equipment reached consensus with 80.00% or higher level of agreement

The panel of experts failed to reach a consensus on tools and equipment for eight areas in the CASE Agricultural Power and Technology curriculum.

Table 8

Delphi Round Three: Tools & Equipment Needed that Did Not Reach Consensus for the CASE Agricultural Power and Technology Curriculum (n = 13)

Tools & Equipment		Yes (%)	No (%)
Q4	Diesel engines	75.00	25.00
	Surveying equipment	66.67	33.33
Q6	Aprons; Accident handling; Safety color and zones	75.00	25.00
	Computers; Textbooks	66.67	33.33
Q8	Lab coats	72.73	27.27
	DVD's	54.55	45.45
Q10	Modern machinery with modern problems	72.73	27.27
Q12	Wood lathe	72.73	27.27
	Auto level; laser cutter	63.64	36.36
Q20	Electric welders	72.73	27.27
Q25	PVC Connections and fittings	72.73	27.27
Q29	Clear Briggs carburetor	72.73	27.27

Discussion, Conclusions, Implications, and Recommendations

The researchers believe that Post-Secondary Applied STEM Learning Laboratories will need to be updated to support pre-service teacher STEM content integration in agricultural mechanics, meeting the needs of a changing world based upon the results of this study. Out of the 413 tools that were identified by the panel of experts, 409 tools were identified as agree or strongly agree. The experts were uncertain of only four tools and did not disagree with a single tool included in the list. With the considerable number of tools identified by the panel of experts (*413*), it is understandable that McCubbins et al., (2016) identified a shortage of tools needed to teach agricultural mechanics courses. If you look closer at the tools identified by the panel of experts, an overwhelming majority of the tools identified would be what you would find in a standard agricultural mechanics laboratory. Therefore, the costs associated with the transition from a traditional agricultural mechanics laboratory to a Post-Secondary Applied STEM Learning Laboratory should be minimal, assuming the number of tools and equipment currently available is adequate.

The panel of experts identified in the initial round a need for STEM enhanced technology (i.e., microscopes, digital multimeters, calibration equipment, laser cutters, etc.) but only one; Precision Measuring Equipment (Micrometers & Calipers)-achieved a dichotomous consensus in round three of 100%. The panel of experts was uncertain as to the value of other STEM enhanced technology as worthy of inclusion in a Post-Secondary Applied STEM Learning Lab facility. Is it possible that the panel of experts' views current best practices in agricultural mechanics as being STEM enhanced? Is it possible that the growing trend of students possessing basic agricultural mechanics skills is limiting the potential of educators to institute a STEM enhanced curriculum? Furthermore, with the current skills gap and the need for skilled laborers, is there a need for a STEM enhanced curriculum? With this concern, future research should attempt to identify the basic skills needed in an introductory agricultural mechanics course.

Implications of this research exist regarding future teacher preparation. Since exposure to a STEM-enhanced curriculum could potentially reinforce student learning and competency in

STEM areas (Haynes, et al., 2012; Myers & Dyer, 2006; Parr, et al., 2006; Thompson & Balschweid, 2000), it stands to reason that teacher education programs need to provide future teachers with the tools and facilities necessary to effectively integrate and emphasize STEM principles into agriculture content (Johnson, 2012; Stohlmann, et al., 2012). As such, could increased exposure to a Post-Secondary Applied STEM Learning Laboratory influence the abilities of teachers to effectively integrate STEM content? Future research should investigate this possibility.

References

Agnew, D. M., & Shinn, G. (1987). Importance of mechanical activities performed by outstanding young farmers In Mississippi. *Journal of Agricultural Education*, *28*(3), 29–36. https://doi.org/10.5032/jaatea.1987.03029

Anderson, R. G. & Anderson, K. (2018). Career and technical education teachers' tool and equipment availability related to the teaching and learning of two-stroke engines content: A preliminary study. *Career and Technical Education Research Journal, 43*(3) 213-226. https://doi.org/10.5328/cter43.3.213

Anderson, R. & Swafford, M. (2021). Perceptions of administrators in Kentucky secondary schools regarding agriculture and mathematics, teaching integrated mathematics and meeting state standards. *The CTE Journal, 9*(1). 1-12.

Babalola, J. B. (2003). Budget preparation and expenditure control in education. In J. B. Babalola (Ed.) *Basic text in educational planning* (pps). Ibadan: Awemark Industrial Printers.

Balschweid, M. A. (2002). Teaching biology using agriculture as the context: Perceptions of high school students. *Journal of Agricultural Education*, 43(2), 56–67. doi: 10.5032/jae.2002.02056

Barack Obama and Joe Biden's Plan for Lifetime Success Through Education. (2009). https://googlegroups.com/group/macareers11/attach/2ca924ca2391ef2a/PreK-12EducationFactSheet%5B1%5D.pdf?part=0.1&view=1 Barak, M., and Dori, Y. J. (2005). Enhancing undergraduate students' chemistry understanding through project-based learning in an IT environment. *Science Education, 89*(1) 117–39.

Barak, M. & Dori, Y. (2005). Enhancing undergraduate students' chemistry understanding through project-based learning in an IT environment. *Science Education 89*(1): 117-139.

Beaulieu, L. J., & Mulkey, D. (1995). *Investing in people: The human capital needs of rural America.* Westview Press, Inc.

Blackburn, J. J., & Kelsey, K. D. (2012). *A case study of authentic assessment in a secondary agricultural mechanics laboratory*. Proceedings from the 2012 Southern Region of the American Association for Agricultural Education Research Conference. Birmingham, AL: 32-46.

Byrd, A. P., Anderson, R. G., & Paulsen, T. H. (2015). Does agricultural mechanics laboratory size affect agricultural education teachers' job satisfaction. *Journal of Agricultural Education*, *56*(1), 6–19. https://doi.org/10.5032/jae.2015.01006

Curriculum for Agricultural Science Education. (February 2014) *CASE vision*. http://www.case4learning.org

Curry, K. W., Jr., Wilson, E., Flowers, J. L., & Farin, C. E. (2012). Scientific basis vs. contextualized teaching and learning: The effect on the achievement of postsecondary students. *Journal of Agricultural Education*, *53*(1), 57–66. doi: 10.5032/jae.2012.01057

Dalkey, N. C. (1969). *The Delphi method: An experimental study of group opinion.* The Rand Corporation.

Delp, P., Thesen, A., Motiwalla, J., & Seshadri, N. (1977). *Delphi: System tools for project planning.* National Center for Research in Vocational Education, The Ohio State University.

Dewey, J. (1938). Experience and education. Collier Books.

Doerfert, D. (2011). *National Research Agenda: American Association for Agricultural Education's research priority areas for 2011-2015*. Lubbock, TX: Texas Tech University, Dept. of Agricultural Education and Communications.

ERIC Clearinghouse on Adult, Career, and Vocational Education & ERIC Clearinghouse on Teaching and Teacher Education. (1998). *Contextual teaching and learning: Preparing teachers to enhance student success in the workplace and beyond.* Information series no. 376. Center on Education and Training for Employment.

Habibi, A., Sarafrazi, A., & Izadyar, S. (2014). Delphi technique theoretical framework in qualitative research. *The International Journal of Engineering and Science* 3(4), 8-13.

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

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

Hasson, F., Keeney, S., & McKenna, H. (2000). Research guidelines for the Delphi survey technique. *Journal of Advanced Nursing*, 32(4), 1008-1015. doi:10.1046/j.1365-2648.2000.t01-1-01567.x

Haynes, J. C., Gill, B. E., Chumbley, S. B., & Slater, T. F. (2014). A cross-case comparison of the academic integration human capital pre-service agricultural educators retain prior to their teaching internship. *Journal of Agricultural Education, 55*(5), 191-206. doi: 10.5032/jae.2014.05191

Haynes, J. C., Robinson, J. S., Edwards, M. C., & Key, J. P. (2012). Assesing the effect of using a science-enhanced curriculum to improve agriculture students' science scores: A causal comparative study. *Journal of Agricultural Education, 53*(2), 15–27. doi: 10.5032/jae.2012.02015

Johnson, C. C. (2012). Implementation of STEM education policy: Challenges, progress, and lessons learned. *School Science and Mathematics, 112*(1), 45–55. doi: 10.1111/j.1949-8594.2011.00110.x

Johnson, C. C. (2013). Conceptualizing integrated STEM education. *School Science and Mathematics, 113*(8), 367–368. doi: 10.1111/ssm.12043

McCubbins, O., Anderson, R., Paulsen, T. & Wells, T. (2016). Teacher-perceived adequacy of tools and equipment available to teach agricultural mechanics. *Journal of Agricultural Education, 57(3), 223-236. doi: 10.5032/jae.2016.03223*

McCubbins, O., Wells, T., Anderson, R. & Paulsen, T. (2017). Examining the relationship between the perceived adequacy of tools and equipment and the perceived competency to teach agricultural mechanics. *Journal of Agricultural Education, 58*(2), 268-283. *https://doi.org/10.5032/jae.2017.02268*

Myers, B. E., & Dyer, J. E. (2006). Effects of investigative laboratory instruction on content knowledge and science process skill achievement across learning styles. *Journal of Agricultural Education, 47*(4), 52–63. doi: 10.5032/jae.2006.04052

National Center for Education Statistics. (2005). *NAEP state comparisons – data table*. http://nces.ed.gov/nationsreportcard/statecomparisons/withinyear.aspx?usrSelections=1%2cSCI%2c0%2c2%2cwithin%2c0%2c0.

National Research Council. (1996). *National science education standards*. National Academy Press.

National Science Board (NSB) (2010). Science and engineering indicators 2010, NSB 10-01, National Science Foundation.

Oakes, J., & Saunders, M. (2002, October). Access to textbooks, instructional materials, equipment, and technology: Inadequacy and inequality in California's public schools. http://escholarship.org/uc/item/4ht4z71v

Olaniyan, D. A., & Okemakinde, T. (2008). Human capital theory: Implications for educational development. *European Journal of Scientific Research, 24*(2), 157-162.

Parr, B. A., Edwards, M. C., & Leising, J. G. (2006). Effects of a 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

Psacharopoulos, G., & Woodhall, M. (1997). *Education for development: An analysis of Investment Choice.* Oxford University Press.

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

Robinson, J. S., Krysher, S., Haynes, J. C., & Edwards, M. C. (2010). How Oklahoma state university students spent their time student teaching in agricultural education: A fall versus spring semester comparison with implications for teacher education. *Journal of Agricultural Education 51*(4), 142–153. doi: 10.5032/jae.2010.04142

Sakamota, A., & Powers, P. A. (1995). Education and the dual labour market for Japanaese men. *American Sociological Review, 60*(2), 222-246. doi: 10.2307/2096385

Schultz, T. W. (1971). *Investment in human capital: The role of education and research.* The Free Press.

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

Skulmoski, G. J., Hartman, F. T., & Krahn, J. (2007). The Delphi method for graduate research. *Journal of Information Technology Education: Research*, 6(1), 1-21.https://www.learntechlib.org/p/111405/

Stohlmann, M., Moore, T. J., & Roehrig, G. H. (2012). Considerations for teaching integrated STEM education. *Journal of Pre-College Engineering Education Research (J-PEER), 2*(1), 23–34. doi: 10.5703/1288284314653

Sutphin, H. D. (1984). SOE: Laboratories. *The Agricultural Education Magazine*, 56(10), 4. http://www.naae.org/links/agedmagazine/archive/Volume56/v56i10.pd

Swanson, R. A., & Holton, E. F. (2009). *Foundations of human resource development*. Berrett-Koehler Publishers.

The Council. (2024). CASE *Curriculum standards alignment*. https://www.case4learning.org/curriculum/standards-alignment/

Thompson, G. W., & Balschweid, M. A. (1999). Attitudes of Oregon agricultural science and technology teachers toward integrating science. *Journal of Agricultural Education, 40*(3), 21–29. doi: 10.5032/jae.1999.03021

Thompson, G. W., & Balschweid, M. A. (2000). Integrating science into agriculture programs: Implications for addressing state standards and teacher preparation programs. *Journal of Agricultural Education, 41*(2), 73–80. doi: 10.5032/jae.2000.02073

Tschannen-Moran, M., & Woolfolk Hoy, A. (2002, April). *The influence of resources and support on teachers' efficacy beliefs.* Paper session presented at the annual meeting the American Educational Research Association, Louisiana.

Yun, G. W., & Trumbo, C. W. (2000). Comparative response to a survey executed by post, e-mail, & web form. *Journal of Computer‐Mediated Communication*, 6(1). doi:10.1111/j.1083-6101.2000.tb00112.x

Appendix 1 Delphi STEM Data Round 1	
Q1.	A/V capacity, Accompanying SDSs (Safety Data Sheets), Adequate square footage of laboratory space per student/worker, Alternative energy source equipment for demonstrations, Appropriate lighting, Appropriate space, Appropriately designed facility with both open space for students to work independently and in small groups, Bench equipment, Building supplies, CAD software, CNC capabilities, Computers, Concrete tools, Cutting rigs, Dedicated work areas in the facility, Diagnostic tools, Dynameter, Electrical wiring components, Energy converters, Everyday items that display the use of simple machines, Fasteners, Gear pullers, Generic Hand tools, GPS equipment, Hand tools, Jack stands, Jacks, Lab safety materials, Learning activities to illustrate mechanical applications in food, agriculture, and natural resources, Measuring equipment, Microscopes, Plumbing supplies, Pneumatic power, Power equipment, Power generation as in energy and fuel, Power tools, Precision Measurement tools, Safety apparel such as glasses, face shields, wash basin, etc., Safety Training, Simulated events (engine problem diagnostic, hydraulic component failure/diagnosis, equipment repair) provided by industrial counterparts, Shop tables based on enrollment expectations, Small gas engines, Small gas engines tools, Tables, Teaching Aids (video conferencing/recording abilities, projectors, class computers, etc.), Text resources, Ventilation, Vises, Welders, Welding supplies: Arc, MIG, Oxy, White board space, Wood shop tools for construction and woodworking
Q2.	Ag Power (small gas engines, tools), Band saw (wood and metal), Building supplies, C2H2 - O2 setups for cut and weld applications, CNC plasma cam, Compound miter saw, Computer driven technology machines also needed such as plasma, laser cutter, CO2 engraver, wood shaper, Computers, Concrete tools, Construction (woodworking tools, lumber, fasteners, etc.), Crack and leak testing, Cutting rigs, Diagnostic capable computer station, Diesel engines, Digital camera, Dmm, Electrical (electrical tools, wire, electrical hardware), Electrical motors based on specific amperage, watts and rotation, Electrical Systems Equipment (components for wiring), Electrical wiring components, Engines would need engine sets consisting of single L and OHV, twin and other multiples of cylinders in 2 & 4 stroke configurations, Everyday items that display the use of simple machines, Handouts, Hand tools and fasteners to display basic mechanical operations, such as leverage or torque, Hydraulic demo and testing apparatus, Hydraulic gauge, If world lists are satisfied the basic tools and equipment for hand and power based on the specified area, Large power tools - such as table saw, Laser cutter, Learning activities that illustrate basic physics principles, including measurement and mechanical advantage, Mechanical technology such as SMAW, GTAW, and other fusion based processes would be needed, Metal fabrication equipment, Microscopes, Models, Output equipment such as pulleys, gears, etc., Oxy-acetylene rigs, Parts washers, Planer, Plumbing supplies, Pneumatic tools, Power testing equipment, Power tools, Precision measuring instruments, Pressure testing (hydraulic, fuel, crank), Reference material, Safety equipment, Small gas engines, Small gas engines tools, Surveying (leveling rods, levels, etc.), Surveying instruments, Teaching aids of modern/current equipment and machinery coupled with basic knowledge of said specific skill...laying out a trailer, Test stand of appropriate size and configuration, Textual information, Welders,

	Welding Equipment and Machinery (GMAW, SMAW, GTAW), Welding supplies, Wood lathe, Wood shop tools for construction and woodworking
Q3.	All safety materials (coats, goggles, hearing protection, fire extinguishers, fire blanket.), Aprons, Computers, Consequences as seen in an industrial setting, Curriculum, DVD, Examples of safety tests, Exams, Gloves, Hand tools, Handling accidents, Handouts, Identification and reduction of hazards, Industry validated and up to date safety curriculum, Lab coats, Lab layout guidelines, Lab management guidelines, Learning activities that teach the concepts of shop organization, Online resources, Permanent safety features such as ventilation, Posters, Power tools, PPE - safety glasses, Protective safety equipment, Safety colors and zones, Safety contracts, Safety Equipment (fire extinguishers, blanket, fire alarm), Safety exams, Safety glasses, Safety protocol, Safety slides, Shields, Shop safety rules/tests, State/national shop safety guidelines, Teaching aids (computers, video abilities, etc.), Textbooks, The value of cleanliness and organization, Tool specific safety rules, Variety of PPE, Ventilation system(S), Wash basins, Welding helmets
Q4.	Clean-up/maintenance guidelines, Computers, Consumables, Curriculum, DVD, Gloves, Good working equipment that has all their safety features, Hand and power tools, Hand tools, Handouts and exams, Lab coats, Larger stationary equipment (drill press, metal breaks, etc.), Learning activities that emphasize the safe use of hand tools and power tools, Machine and tools being taught to cover areas of welding, metal work, small engines, and woodwork, Modern and current machine tools that will actually be seen not only by those going into the teaching field, but also by those that will be entering the workforce either after secondary graduation, or after they graduate high school, Online resources, Posters, Power tools, PPE (Personal Protective Equipment), Safety contracts, Safety exams, Safety rules/test for each, Safety slides, Specific application safety items, Teaching aids (computers, video abilities, etc.), Textbooks, Tool area use guards and markers, Tool specific safety rules, Tools (hand and power) to demonstrate safe operating procedures, Videos of safe operation, Welding helmets
Q5.	Modern machinery with modern problems, Basic tools of measurement including dimensions, weight, volume, etc., Calculators, Combination square, Curriculum, Dial calipers, Dial gauges, Direct and indirect measuring tools, DVD, Feeler gauges, Framing square, Hand and power tools, Handouts and exams, Inside/outside calipers, Levels, Materials for measuring/mixing liquids, Measurement conversion charts, Micrometers, Online resources, Posters, Precision measuring equipment (surveying equipment, micrometers, calipers, etc.), Rulers, Safety slides, Squares, Steel rule, Surveying equipment, Tape measure (various lengths), Tape measures (log tape, fiberglass tape, standard lumber tape, survey instruments), Teaching aids (computers, video abilities, etc.), Teaching material such as "The Big Inch", Torque wrenches, Traditional measuring tools, i.e., steel tape, yard sticks, ruler, Transits, Tri-square
Q6.	Auto level, Band saw, Building materials, CAD for design, Compound miter saw, Concrete & masonry, Couple the doing with a design that has engineering components so that students understand the "why" of nailing a board in a certain place or what a heat affected zone in metal really translates into, Cross/rip saw, Designing tools, Fasteners, Framing squares, Hammers, Jig/sabre saw, Laser cutter, Laser level, Learning activities that illustrate basic design elements for structures and buildings including pole and balloon construction, Planer, Plumb bob, Portable circular saw, Room to build a structure, Squares (rafter, tri, tri-miter, combination), Structural design guidelines, Surveying equipment, Table saw, Tables with clamps, The ability with tools and space to construct a project that one would see in agriculture. Be it a building or a metal project (trailer, piece of equipment), Wheel barrow, Wood clamps (safety?), Wood lathe, Woodworking (building floors, wall, roofs, etc.)
Q7.	Access to the different mechanical fluids, Cylinders, Fluid, Fluid trainers, Fuels, Hoses, Hydraulic and pneumatic information, Hydraulic components one would see in agriculture, Hydraulic systems, Hydraulic trainers, In addition to identification of these fluids, a lot of class time going over the math of flow rates and uses are needed, Learning activities that illustrate the principles of hydraulics, Materials related to creating proper drainage around ag buildings, Oils, Pneumatics, Rain water runoff, Syringes, tubing, small lumber, associated tools, Training stations, Viscometer

Q8.	A land lab, Auto and laser level, Building codes for different soil types and areas, Computer, EDM (Electronic Distance Measuring), Equipment for soil samples, Flags, Hand tools (shovels), Learning activities that involve the selection and use of building materials including soil and concrete, Levels, Natural resources for teaching, Rod, Smart board, Stakes, Surveying and land layout materials (transit, rods), Surveying equipment, Surveyor's tape, Tractor/skid loaders for moving earthen materials, Wheel barrow
Q9.	Arc Welders, Band saw, Basic concrete tools, Basic metal tools, Basic wood tools, CAD equipment, CNC equipment, Composite construction materials, Compound miter saw, Fasteners, Hammers, Jigsaw, Jointer, Metal construction materials, Metal cutting band saw, Metal lathe, MIG Welders, Oxy-fuel cutting equipment, panel saw, Pedestal grinder, Personal Protective Equipment, Planer, Plasma cutting equipment, Pneumatic nail gun, Portable circular saw, Portable drill press, Portable grinder, Reciprocating saw, Sawhorse, Sheet metal break, Table saw, TIG Welders, Vises, Welding rods, Wood clamps, Wood construction materials, Wood storage racks
Q10.	Electric welders, Fuel and energy storage cabinet, Heat source, IR cameras to detect heat loss, Learning activities that include the concepts of energy, Learning activities that includes the measurement of energy, Ovens, Oxy-fuel set ups, Propane torch, Small gasoline engines, Teaching aids on heat energy
Q11.	All electrical tools and fixtures, Basic electrical teaching aids, Circuit breakers, Electric motor controls, Electrical distribution, Electrical generation, Electrical meters, Electrical motors, Electrical pliers, Junction boxes, Light fixtures, Line meter, Measurements, Motion controls, Multi-meters, Needle nose pliers, Outlets, Power transfer safety device, Principles of AC electrical power, Principles of DC electrical power, Screwdrivers, Small engines, Switches, Thermostats, Wire, Wire nuts, Wiring boards
Q12.	Fluid power equipment, Hydraulic power equipment, Hydraulic trainer
Q13.	All alternative energy items, Electrical motor (12v), Generation and storage of chemical electricity, Generation and storage of solar electricity, Generation and storage of wind electricity, PVC connections, PVC fittings, Solar panels, Tanks, Viable renewable energy teaching aids, Windmills
Q14.	Basic shops tools, Everyday items that display mechanical advantage, Fasteners, Gears to attach to small motors used in course, Hand tools, Handouts, Learning activities that illustrate basic principles of physics, Legos, Power points, Pulleys to attach to small motors used in course, Simple aids such as pulleys, and how they work, Small 12V machine motors
Q15.	Briggs new clear carburetor, Handouts, Hydraulics lab, Learning activities to illustrate how electrical energy is harnessed to do work, Learning activities to illustrate how hydraulic energy is harnessed to do work, Learning activities to illustrate how mechanical energy is harnessed to do work, Motors and any associated tools, Power points, Small gas engines, Teaching aids, Videos of the actual movement of engine parts
Q16.	Basic wiring principles, Handouts, Hydraulics lab, Power points, Teaching aids covering bearings, Teaching aids covering belts, Teaching aids covering gears
Q17.	Engine performance testing equipment
Q18.	Aids to monitor power and how conditions affect power, Measurement of electrical and fuel power consumption, Tools for calibration
Q19.	Basic shop tools, Computer, Learning activities that require reading and problem solving, Problems using real world items

	Basic plan reading, Computer-aided design programs
Q20.	A real project that takes real management and oversight, Plans, Reference material, Software, Videos
Q21.	Performance testing equipment, Reference material
Q22.	
Q23.	Computers, Learning activities that illustrate the uses of tools and equipment to perform functions, bring concepts to reality, and to address needs

Appendix 2

Panel of Experts Demographics (n = 11)

Demographic Variables	*f*	%
Gender		
Male	11	100.00
Female	0	0.00
Racial/Ethnic Heritage		
Native American	0	0.00
African American	0	0.00
White, Non-Hispanic	11	100.00
Hispanic	0	0.00
Asian, Pacific-Islander	0	0.00
Years Teaching Experience		
0-10	5	45.45
11-20	2	18.18
21-30	0	0.00
31-40	3	27.27
>40	1	9.09
Educational Level Currently Teaching		
Secondary Education	0	0.00
Post-Secondary Education	11	100.00
Industry Employment	0	0.00
Number of APT Courses Currently Teaching		
0	1	9.09
1 - 2	9	81.8
3 - 4	1	9.09
NAAE Region Affiliation		
Region 1	0	0.00
Region 2	3	37.50
Region 3	4	50.00
Region 4	0	0.00
Region 5	0	0.00
Region 6	1	12.50