Using a Logistic Regression Approach to Estimate the Influence of Demographical Factors on Small Engine and Welding Competencies of Secondary Agricultural Education Teachers

Douglas D. LaVergne*
Rafael Bakhtavoryan
Robert L. Williams
Texas A&M University – Commerce, College of Agricultural Sciences and Natural Resources, PO Box 3011, Commerce, TX 75429

ABSTRACT

A logistic regression model was used to examine the impact of demographical characteristics of secondary agricultural education teachers in Northeast Texas on their small gasoline engines and welding competencies. Data were collected using a web-based questionnaire and employing a non-proportional stratified random sampling technique with 150 agricultural education teachers participating in the study. Findings showed that being male and having agricultural mechanical courses in both high school and college were positively associated with being competent in small gasoline engines. Being male was also positively associated with being competent in welding, while having only a Bachelor's degree (as compared to a Master's degree) was negatively associated with being competent in welding. Additional research should be conducted to understand better why these differences exist.

KEYWORDS: agricultural mechanical competency; small gasoline engines; welding; logistic regression

INTRODUCTION

Agricultural mechanical competency continues to be a critical element of secondary agricultural education programs. As teacher education programs continue to maintain relevant and progressive agricultural mechanical curriculums, the need to ensure that competency within the mandated curriculum is ever more important. However, due to the broad spectrum of agricultural mechanics, teacher preparation programs often must strategically appropriate resources to ensure that the important areas of agricultural mechanics are taught to their students. Burris et al. (2005) reported that providing secondary students with adequate opportunities to acquire necessary technical competencies in agriculture is challenging when considering the subject of agricultural mechanics. As such, to develop competent teachers, it is the responsibility of the agricultural education teacher and the teacher preparation program to constantly seek the technical relevance that guides agricultural mechanics. Byrd et al. (2015) reported that with a large percentage of time spent in an agricultural mechanics laboratory, secondary and

* Corresponding author: doug.lavergne@tamuc.edu

pre-service agricultural education teacher candidates must have competence in multiple skills to teach agricultural mechanics effectively. Competent agricultural mechanical teachers are the foundation to high quality teaching. Creating teacher candidates who can effectively guide agricultural education students to technical competency will ensure that the profession remains important in an industry-validated society (Leiby et al. 2013).

Agricultural Mechanical Competency. Agricultural mechanics is a content area that is comprised of over 50 skills (Shultz et al. 2014) varying in levels of importance specified by each agricultural program (Burris et al. 2005). Because of its broad depth, teacher preparation programs typically provide their pre-service teachers with the training necessary to be successful based upon industry-validated skills (Roberts and Ball 2009). Agricultural mechanical competencies among in-service educators have been attributed to job satisfaction (Rice et al. 2011) and teacher effectiveness (Anderson 2004), which can often lead to a teacher's motivation to remain in the field (Davis and Wilson 2000). Despite its importance, research has indicated that restricted degree plans (Burris et al. 2005) coupled with the inappropriate resources to teach certain competencies of agricultural mechanics (Byrd et al. 2015) have often limited the teacher education program's ability to develop competent agricultural educators. In a study regarding the importance of teaching agricultural mechanical competencies to pre-service teachers, Burris et al. (2005) reported that teacher educators knew the instruction of agricultural mechanics was important but the level of preparation that the pre-service educators received was not sufficient for future duties as a secondary agricultural educator. Moreover, Hubert and Leising (2000) reported that the teacher preparation programs may not provide early career teachers with the proper experience to manage a dynamic learning environment such as the agricultural mechanics laboratory.

Ensuring that agricultural education teachers maintain agricultural mechanical competency should be paramount to teacher preparation programs and school districts where these programs exist. With a large percentage of students seeking agricultural mechanics courses at the secondary level, the need to assess the agricultural mechanical competencies of in-service teachers strengthens the profession's capacity to ensure that the curriculum maintains its longstanding and significant part in secondary agricultural education. Saucier and McKim (2011) reported that well-prepared and knowledgeable agriculture teachers can guide students safely and effectively in the development of practical, hands-on skills and agricultural mechanics education.

Finally, the empirical findings of this study can help interested parties in designing strategies to promote and enhance agricultural mechanical competency among agricultural education teachers. Particularly, interested parties will gain valuable information on the determinants of agricultural mechanical competency associated with small gasoline engines and welding for agricultural education teachers, so that they can focus on them in an attempt to enhance these particular competencies.

Objective. The objective of this study was to identify the statistically significant ($p < .05$) demographical factors influencing agricultural mechanical competency in small gasoline engines and welding for in-service agricultural education teachers in Northeast Texas. The two competencies were chosen based upon previous research indicating competency importance (LaVergne and Williams 2016) and the frequency with which small gasoline engines and welding are taught in agricultural education programs across the country (Shultz et al. 2014; Blackburn et al. 2015; Leiby et al. 2013). Unlike previous research, the present study used an empirical approach for analyzing the drivers of the agricultural mechanical competency associated with small gasoline engines and welding for agricultural education teachers in Northeast Texas.

MATERIALS AND METHODS

Methodology. A logistic regression analysis was carried out using cross-sectional data collected within the study. The choice of the logistic regression is explained by the binary dependent variable assuming the value of one if the event happens (i.e., if the respondent is competent), and zero otherwise (i.e., if the respondent is not competent). In contrast to the previous research, this analysis contributes to the current literature by conducting an empirical investigation between agricultural mechanical competency and a set of demographical variables focusing on in-service agricultural education teachers in Northeast Texas.

To evaluate the likelihood of being competent in small gasoline engines and welding in relation to demographical factors, binomial logit analysis was conducted. Overall, two logistic regressions were estimated with one for competency in small gasoline engines and the other for competency in welding. The logit model utilized in the present study is specified as follows:

$$P(y=1|x) = \frac{\exp(\boldsymbol{\alpha\prime x})}{1-\exp(\boldsymbol{\alpha\prime x})}, \tag{1}$$

where P stands for the probability of the event occurring, y=1, (a respondent is competent in small gasoline engines for the small gasoline engines model, a respondent is competent in welding for the welding model), **x** is a vector of independent demographical variables, and α' is a conformable vector of parameters to be estimated. The probability of the event not occurring, y=0, (a respondent is not competent in small gasoline engines for the small gasoline engines model, respondent is not competent in welding for the welding model), is calculated as:

$$P(y=0|x) = 1 - P(y=1|x). \tag{2}$$

Transformation of the dependent variable into the logarithm of the odds ratio,ln $\frac{p}{1-p}$, and incorporation of the random error term ε, yield the following logit model:

$$\ln\left(\frac{P}{1-P}\right) = \alpha'\boldsymbol{x} + \varepsilon. \tag{3}$$

Equation in (3) was estimated using the maximum likelihood approach. The interpretation of the model coefficients was done using the percentage change in the odds ratios. The odds ratios were calculated by exponentiating the values of the logit coefficients (i.e., $exp^{\alpha i}$), and the percentage change in the odds ratios were calculated as ($e^{\alpha i}$ -1)*100.

The empirical specification of the logit model with the binary dependent variable modeled as a function of a set of demographical factors expected to affect the probability of being competent in small gasoline engines for in-service agricultural education teachers in Northeast Texas is specified as follows:

$$Pr(smgaseng\_comp = 1) = F(\alpha_0 + \alpha_1 male + \alpha_2 age\_20\_35 + \alpha_3 age\_36\_50 + \alpha_4 bachelors\_educ + \alpha_5 Texas\_ffa\_area\_teach\_5 + \alpha_6 Texas\_ffa\_area\_teach\_6 + \alpha_7 years\_teach\_5\_or\_less + \alpha_8 years\_teach\_6\_15 + \alpha_9 school\_dist\_rural + \alpha_{10} agmech\_course\_highsch\_1\_2 + \alpha_{11} agmech\_course\_highsch\_3\_4 + \alpha_{12} agmech\_course\_highsch\_5\_more + \alpha_{13} agmech\_course\_college\_1\_2 + \alpha_{14} agmech\_course\_college\_3\_4 + \alpha_{15} agmech\_course\_college\_5\_more + \alpha_{16} agmech\_projectshow\_1\_2 + \alpha_{17} agmech\_projectshow\_3\_more + \alpha_{18} agmech\_cde\_part\_1\_more) \quad (4)$$

where *Pr* is the probability of the agricultural education teacher being competent in small gasoline engines; *F* is the logistic cumulative density function; and αs are the parameters to be estimated. The variables in (4) and their definitions are shown in Table 1.

The welding competency logistic regression model includes the same independent variables as the small gasoline engines competency model; however, the dependent variable in the welding competency model (*welding*) is a dummy variable taking on one if the respondent is competent in welding and zero otherwise.

The Agricultural Mechanic Competency Development survey for 2015 permitted the quantification of all the foregoing variables and the estimation of the coefficients of the model. All the independent variables entered the model as dummy variables with corresponding base categories. Particularly, the base category for *male* was female. For *age_20_35* and *age_36_50*, the base category was age 51 years and above. For *bachelors_educ*, the base category was having Master's level of education. For *Texas _ffa_area_teach_5* and *Texas_ffa_area_teach_6*, the base category was Texas FFA area eight. For *years_teach_5_or_less* and *years_teach_6_15*, the base category was 16 or more years of teaching. For *school_dist_rural*, the base category was suburban or urban school district. For *agmech_course_highsch_1_2*, *agmech_course_highsch_3_4*, and *agmech_course_highsch_5_more*, the base category was no agricultural mechanic courses taken in high school. For *agmech_course_college_1_2*, *agmech_course_college_3_4*, and *agmech_course_college_5_more*, the base category was no agricultural mechanic courses taken in college. For *agmech_projectshow_1_2* and *agmech_projectshow_3_more*, the base category was no participation in agricultural mechanic projects shows on a yearly basis. For *agmech_cde_part_1_more*, the base category was no participation in agricultural mechanic Career Development Events on a yearly basis.

Age, highest level of education completed, years of teaching, the description of school district as rural, number of agricultural mechanic courses taken in high school or college, and participation in agricultural mechanic project shows or Career Development Events were expected to positively affect the likelihood of being competent in small gasoline engines and welding. There was no prior expectation as far as the impact of gender and teaching in a specific Texas FFA area on the likelihood of being competent in small gasoline engines and welding.

Table 1. Variables and their definitions.

Variable	**Definitions**
smgaseng_comp	Dummy dependent variable taking on one if the respondent is competent in small gasoline engines and zero otherwise
male	Dummy variable taking on one if the respondent is a male and zero otherwise
age_20_35	Dummy variable taking on one if the respondent is between 20 and 35 years of age and zero otherwise
age_36_50	Dummy variable taking on one if the respondent is between 36 and 50 years of age and zero otherwise
bachelors_educ	Dummy variable taking on one if the respondent had a Bachelor's degree and zero otherwise
Texas_ffa_area_teach_5	Dummy variable taking on one if the respondent taught in Texas FFA area *5* and zero otherwise
Texas_ffa_area_teach_6	Dummy variable taking on one if the respondent taught in Texas FFA area *6* and zero otherwise
years_teach_5_or_less	Dummy variable taking on one if the respondent had been teaching for *5* years or less and zero otherwise
years_teach_6_15	Dummy variable taking on one if the respondent had been teaching for more than *6* and less than 15 years and zero otherwise
school_dist_rural	Dummy variable taking on one if the respondent's school district would be best described as rural and zero otherwise
agmech_course_highsch_1_2	Dummy variable taking on one if the respondent had taken one or two agricultural mechanic courses in high school and zero otherwise
agmech_course_highsch_3_4	Dummy variable taking on one if the respondent had taken three or four agricultural mechanic courses in high school and zero otherwise
agmech_course_highsch_5_more	Dummy variable taking on one if the respondent had taken five or more agricultural mechanic courses in high school and zero otherwise
agmech_course_college_1_2	Dummy variable taking on one if the respondent had taken one or two agricultural mechanic courses in college and zero otherwise
agmech_course_college_3_4	Dummy variable taking on one if the respondent had taken three or four agricultural mechanic courses in college and zero otherwise
agmech_course_college_5_more	Dummy variable taking on one if the respondent had taken five or more agricultural mechanic courses in college and zero otherwise
agmech_projectshow_1_2	Dummy variable taking on one if the respondent participated in one or two agricultural mechanic projects shows on a yearly basis and zero otherwise

(continues)

Variable	**Definitions**
agmech_projectshow_3_more	Dummy variable taking on one if the respondent participated in three or more agricultural mechanic projects shows on a yearly basis and zero otherwise
agmech_cde_part_1_more	Dummy variable taking on one if the respondent participated in one or more agricultural mechanic Career Development Events on a yearly basis and zero otherwise

Data. Survey research methods were implemented to gather information to describe high school agricultural education teachers' agricultural mechanical competency development from high school through their college matriculation. The target population for this study was all high school agricultural education teachers in areas five, six, and eight as identified by the Texas FFA Organization during the 2015-2016 school year (N = 700). Using a sampling formula from Bartlett et al. (2001), researchers randomly selected 150 teachers (n = 150). The purposeful sample was chosen because of its high alumni agricultural teacher population (of the researching institution) and the possibility of using the data to assess the effectiveness of the teacher preparation curriculum. The questionnaire was developed by the researchers with some questions being modeled after the Rice et al. (2011) study on assessing agricultural mechanic competencies of former high school agricultural education students. Survey implementation and data collection methods followed Dillman et al.'s (2009) *Tailored Designed Method*. A panel of experts with agricultural mechanics teaching experience established content and face validity. Non-response error was addressed by comparing early respondents to late respondents. No significant differences were found. A response rate of 63% was attained (n = 95).

The data used in this study were obtained from the Agricultural Mechanic Competency Development survey for 2015. The sample included a total of 95 respondents who were in-service agricultural education teachers in Northeast Texas. Demographical variables used in the study included gender, age, highest level of education completed, Texas FFA area, years of teaching, school district description, number of agricultural mechanic courses taken in high school and college, and participation in agricultural mechanic projects shows and Career Development Events.

The dependent variable, competency in small gasoline engines, was developed according to the answers to the question asking about the respondents' skill level dealing with the small gasoline engine at the completion of their college career. The dependent variable, competency in welding, was constructed according to the answers to the question asking about the respondents' skill level associated with the welding at the completion of their college career. Gender, age, highest level of education completed, years of teaching, school district description, number of agricultural mechanic courses taken in high school and college, and participation in agricultural mechanic projects shows and Career Development events are self-explanatory. The small gasoline engine and welding competencies for agricultural education teachers was considered for Texas FFA areas five, six, and eight.

The percentages of the respondents for each variable are depicted in Table 2. As Table 2 shows, slightly less than three-quarters (74%) of respondents were competent in small gasoline engines. More than half (51%) of respondents were competent in welding. Slightly more than three-quarters (76%) of respondents were male.

Table 2. Percentages of in-service agricultural education teachers by demographical variables in Northeast Texas, *n* = 95.

Variable	**%**
Competence in small gasoline engines	
Yes	74
No	26
Competence in welding	
Yes	51
No	49
Gender	
Male	76
Female	24
Age	
20_35	46
36_50	35
51_above	19
Education	
Bachelor’s	64
Master’s	36
Texas FFA area	
Area_5	52
Area_6	29
Area_8	19
Years of teaching	
5 or less	34
6_15	31
16 or above	35
School district description	
Rural	65
Suburban or urban	35
Number of ag. mech. courses taken in high school	
None	13
1 or 2	41
3 or 4	34
5 or more	12
Number of ag. mech. courses taken in college	
None	13
1 or 2	27
3 or 4	42
5 or more	18
Ag. mech. projects shows participation per year	
None	33
1 or 2	36
3 or more	31
Ag. mech. Career Development Events	
None	60
1 or more	40

[1]Authors’ own calculations.

Almost half (46%) of respondents were between 20 and 35 years of age. Sixty-four percent of respondents had completed a Bachelor's degree. Slightly more than half (52%) of respondents were from Texas FFA area five. Approximately one-third (35%) of respondents had 16 or more years of teaching experience. Sixty-five percent of respondents described their school district as rural.

Forty-one percent of respondents had taken one or two agricultural mechanic courses in high school. Forty-two percent of respondents had taken three or four agricultural mechanic courses in college. Slightly more than one-third (36%) of respondents participated in one or two agricultural mechanic projects shows per year. Finally, 60% of respondents did not take part in Career Development Events on a yearly basis.

As such, a profile of a typical in-service agricultural education teacher from Northeast Texas would include a male respondent who is competent in both small gasoline engines and welding that is aged between 20 and 35. In addition, this individual possess a Bachelor's degree, teaches in Texas FFA area five, has 16 or more years of teaching experience in a rural school district, and has between one to two agricultural mechanic courses in high school. Finally, this individual takes three to four agricultural mechanic courses in college, participates in one to two agricultural mechanic projects shows per year, and does not participate in Career Development Events competitions on a yearly basis.

RESULTS

Table 3 shows the percentage change in the odds ratios that were obtained using STATA 12 software package for small gasoline engines and welding models. The following discussion of the estimation results is conducted only in terms of statistically significant percentage change in the odds ratios, using the 5% significance level ($p < .05$).

Compared to female, being male increased the odds of being competent in small gasoline engines by 412%, holding everything else constant. Relative to not completing agricultural mechanic courses in high school, taking three or four agricultural mechanic courses in high school increased the odds of being competent in small gasoline engines by 1,574%, holding everything else constant. Relative to taking no agricultural mechanic courses in college, taking five or more agricultural mechanic courses in college increased the odds of being competent in small gasoline engines by 4,568%, holding everything else constant. The effects of other variables on the probability of being competent in small gasoline engines were not statistically significant ($p < .05$).

Compared to female, being male increased the odds of being competent in welding by 1,792%, holding everything else constant. Relative to having a Master's degree, having a Bachelor's degree decreased the odds of being competent in welding by 76%, holding everything else constant. The effects of other variables on the probability of being competent in welding were not statistically significant ($p < .05$).

Table 3. Percentage change in the odds ratios, n = 95.

Variable	Small Gasoline Engine % change in the odds ratios	Welding % change in the odds ratios
Gender (base: Female)		
Male	412*	1,792*
Age (base: 51 and above)		
20-35	20	18
36-50	-30	136
Education (base: Master's)		
Bachelor's	-42	-76*
Texas FFA area (base: Area_8)		
Area 5	-66	8
Area 6	-24	-55
Years of teaching (base: 16 or more)		
5 or less	60	600
6-15	-27	98
School district description (base: Suburban or urban)		
Rural	-38	-27
Number of ag. mech. courses taken in high school (base: none)		
1 or 2	44	-23
3 or 4	1,574*	24
5 or more	-51	-73
Number of ag. mech. courses taken in college (base: none)		
1 or 2	9	77
3 or 4	285	181
5 or more	4,568*	912
Ag. mech. projects shows participation per year (base: none)		
1 or 2	-61	268
3 or more	-22	298
Ag. mech. Career Development Events (base: none)		
1 or more	12	-56
constant	-15	-97

[1] Authors' own calculations.
[2] Likelihood ratio χ^2 was 31.56 with the p-value of 0.0248 and 34.66 with the p-value of 0.0104 for small gasoline engines and welding, respectively.
[3] Pseudo R^2 was 0.2882 and 0.2632 for small gasoline engines and welding, respectively.
[4] Asterisk indicates statistical significance at the 5% level ($p < .05$).

CONCLUSION AND DISCUSSION

Although teachers not participating in this study may share similar characteristics, caution must be exercised when generalizing the results of this study. Logit models were estimated to assess the impact of demographical characteristics of in-service agricultural education teachers on their probability of being competent in small gasoline engines and welding. The gender reported by respondents was a statistically significant ($p < .05$) determinant of the competency in small gasoline engines and welding. In particular, this finding indicated that male teachers were more competent in teaching small gasoline engines and welding than their female counterparts. Given the demographical make-up of the teaching area defined in this study, the difference may be attributed partially to the fact that male respondents outnumber female respondent by a 3:1 ratio. However, based upon reported national trends in agricultural education indicating the gender shift of more female agricultural educators than males (Smith et al. 2017), future research should be conducted to determine why this lack of competence exist.

Results of the study revealed that taking agricultural mechanical courses in high school and college were statistically significant ($p < .05$) demographical factors for being competent in small gasoline engines. These findings suggest that if an individual takes agricultural mechanical courses in high school and college, they will gain the skills necessary to become competent in small gasoline engines. Given the importance of small gasoline engines within the agricultural mechanical curriculum, additional research should be conducted to examine the extent to which teacher preparation programs provide pre-service educators with small gasoline engines competence. However, with restricting degree programs often requiring teacher preparation programs to scale back on suggestive coursework (Burris et al. 2005), efforts may need to focus on revising teacher preparation programs to require these courses. As Burris et al. (2005) reported, agricultural mechanics has traditionally been a cornerstone in the secondary agricultural education program. Furthermore, if agricultural mechanics is to remain "industry-validated" (Roberts and Ball 2009), providing pre-service educators with these skills is paramount.

Education was found to be a statistically significant ($p < .05$) determinant for being competent in welding. Compared to having a Master's degree, having only a Bachelor's degree was negatively associated with welding competency. In particular, relative to having a Master's degree, having only a Bachelor's degree decreased the odds of being competent in welding by 76%, holding everything else constant. This finding suggests that respondents with an advanced degree had gained significant confidence in their welding competence. Perhaps, this difference can be attributed to graduate-level coursework in agricultural mechanics. A question that may seem appropriate is "did those respondents with Master's degrees get exposed to advanced courses that allowed them to hone their welding skills?" As such, additional research should be placed on exploring why these differences exist. At minimum, addressing this discrepancy could uncover additional opportunities to agricultural educators that may not have been available to them.

Overall, this study contributes to the area of research dealing with agricultural mechanical competency for in-service agricultural education teachers and can be replicated for other agricultural mechanical competencies (for example, plumbing and woodworking).

REFERENCES

Anderson L. 2004. Increasing teacher effectiveness. UNESCO, International Institute for Education Planning. Paris.

Bartlet II JE, Kotrlik JW, Higgins CC. 2001. Organizational research: Determining appropriate sample size in survey research. Info Tech, Learning, Perf J. 19(1): 43-50.

Blackburn JJ, Robinson JS, Field H. 2015. Preservice agriculture teachers' perceived level of readiness in an agricultural mechanics course. J Ag Ed. 56(1): 172-187.

Burris S, Robinson JS, Terry R. 2005. Preparation of Pre-service Teachers in Agricultural Mechanics. J Ag Ed. 46(3): 23-34.

Byrd PA, Anderson RG, Paulsen TH, Shultz MJ. 2015. Does the Number of Post-Secondary Agricultural Mechanics Courses Completed Affect Teacher Competence? J Ag Ed. 56(1): 20-31.

Davis J, Wilson S. 2000. Principals' efforts to empower teachers: Effects on teacher motivation and job satisfaction and stress. The Clearing House. 73(6): 349-353.

Dillman DA, Smyth JD, Christian LM. 2009. Internet, mail, and mixed-mode survey: The tailored design method 3rd ed. Hoboken (NJ): John Wiley and Sons Inc.

Hubert DJ, Leising J. 2000. An assessment of agricultural mechanics course requirements in agriculture teacher education programs in the United States. J So Ag Ed Rsrch. 50(1): 24-31.

LaVergne DD, Williams RL. 2016. How are in-service agricultural education teachers developing and maintaining their agricultural mechanical competency? Poster Session Proceedings of the 35th National Agricultural Mechanics Professional Blue Ribbon Papers Rsrch Conf. Indianapolis (IN).

Leiby BL, Robinson JS, Key JP. 2013. Assessing the impact of a semester-long course in agricultural mechanics on pre-service agricultural education teachers' importance, confidence, and knowledge of welding. J Ag Ed. 54(1): 179-192.

Rice AE, LaVergne DD, Gartin SA. 2011. Assessing the agricultural mechanic competencies of former high school agricultural education students. Poster Session Proceedings of the 2011 North Central Region Conference of the American Assoc for Ag Ed Conf. University Park (PA).

Roberts TG, Ball AL. 2009. Secondary agricultural science as a content and context for teaching. J Ag Ed. 50(1): 81-91.

Saucier PR, McKim BR. 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. J Ag Ed. 52(4): 24-43.

Shultz MJ, Anderson RG, Shultz AM, Paulsen TH. 2014. Importance and capability of teaching agricultural mechanics as perceived by secondary agricultural educators. J Ag Ed. 55(2): 48-65.

Smith AR, Lawver, RG, Foster DD. 2017. National Agricultural Education Supply and Demand Study 2016 Executive Summary. Available from: http://aaaeonline.org/Resources/Documents/NSD2016Summary.pdf