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Teacher Differences in Beliefs and Perceptions About Sustainable Agriculture: Influence on the Teaching of High School Agriculture Curriculum

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Abstract

The purpose of the study was to determine agriculture teacher differences in beliefs and perceptions about sustainable agriculture (SA) and the associations of these with the teaching of SA in the 12 states of the Midwest US. A descriptive design using self-administered structured questionnaires with Likert measurements was adopted. A stratified random sample of 844 teachers were self-administered the questionnaires. Data were analyzed by ANOVA by comparing means and conducting post-hoc tests. Teachers who agreed and those who disagreed about SA beliefs had no statistically significant difference in their mean ratings of beliefs about SA. Those who were neutral and those who disagreed about SA beliefs had similar mean ratings. Teachers who agreed with SA beliefs and those who were neutral about SA beliefs had a statistically significant difference in their mean ratings of SA beliefs. All three of those groups taught SA topics to a moderate extent. This was not the case for teachers who differed about their perceptions of SA topics/practices. Therefore, teacher differences in beliefs about SA may or may not influence the teaching of SA topics. Teacher perceptions of selected SA practices only influenced the extent to which teachers taught SA. SA goals can be achieved via teaching to influence teacher knowledge, affect, cognition, behavior, and actions towards SA. Teacher professional development needs can be identified from their differences in perceptions about SA practices. An education approach promoting the building of bridges among different perspectives about SA and systems teaching-learning can help to achieve SA goals.

Keywords: agriculture curriculum, agricultural practices, sustainable agriculture, sustainable agriculture practices, teaching methods, teaching practices

1. Introduction

The sustainable agriculture (SA) paradigm promoted by the alternative agriculture movement that reached climax in the 1980s in the US partly contributed to the origin of the Sustainable Agriculture Research and Extension Education (SARE) programs initiated by the US Department of Agriculture (Beus & Dunlap, 1990; Constance, 2010). The SA paradigm challenged the dominant conventional agriculture (CA) paradigm and advocated for the reform of agriculture to embrace SA practices (Beus & Dunlap, 1990: Constance, 2010; Madden, 1998). The agriculture paradigm an individual endorses reflects his/her values about agriculture and can affect his/her cognition, behavior, and actions about SA or CA practice (Beus & Dunlap, 1990; Janker, Mann, & Rist, 2018; Wynne, 2002 cited in Velten, Leventon, Jager, & Newig, 2015). The SARE had a goal to include SA in land-grant research, extension, and education programs (Madden, 1998). Evaluation of SARE has mainly been focused on program- or participant-level outcomes (Kroma & Flora, 2001; Trout, Francis, & Barbuto Jr. et al., 2005; Park & Lohr, 2007; Rassmussen & Kurki, 2007) among researchers, agriculture educators, and farmers. Studies on the impact of SARE on the teaching-learning of the agriculture curriculum at high schools in the Midwest US have been limited, and especially studies on the factors that affect teaching-learning about SA. Factors that are expected to influence the teaching of SA comprise attitudes/beliefs about SA/CA as determined by the agriculture paradigm one endorses (Rasmussen, & Kaltoft, 2003) and the curriculum and its pedagogy or

education (Helms, 2014; Sameipour, 2017).

Few studies conducted in the 1980s and beyond evaluated the impact of the educational component of the SARE (O'Sullivan, 2000; Paulson, 1995). They examined agricultural extension educator attitudes about SA practice and their relationship to the teaching of SA to farmers (Agunga, 1995; Conner & Kolodinsky, 1997). Some studies found educators diverged in attitudes about SA practice and were roughly divided into two camps of equal proportion with opposing views about SA (Conner & Kolodinsky, 1997; Paulson, 1995). Other studies, however, found educators had positive attitudes towards SA practice on average without indicating a divergence of attitudes (O'Sullivan, 2000; Whent, 1997). The studies concluded that extension educators who supported statements on beliefs about SA were motivated to teach or learn about SA more than were those who disagreed (Conner & Kolodinsky, 1997; Udoto & Flowers, 2001; Williams, 2000). The educators had also included more topics to teach farmers about SA than had their colleagues who viewed SA practice negatively.

Comparable studies among high school agriculture teachers established overall teacher agreement with statements supportive of SA practice and found that teachers taught SA topics to a moderate extent (Williams, 2000; Williams & Wise, 1997). Recently, researchers supported the above findings (Muma, Martin, Shelley, & Holmes Jr., 2010; Sameipour, 2017). Other studies found agriculture teachers were neutral to SA practice. They also placed less value in environmental and social dimensions of SA as opposed to the economic dimension (Agbaje, Martin, & Williams, 2001). A number of studies concluded that prior knowledge of SA impacted positively or can impact the attitudes/perceptions of it and/or the use of SA knowledge to teach farmers or high school students about it (Conner & Kolodinsky, 1997; Williams & Wise, 1997; Udoto & Flowers, 2001). The contrary can be true. The mentioned studies concluded that constraints to teaching or learning about SA such as access to curriculum resources and ambiguity and lack of a universally accepted meaning of SA may influence agriculture educators' and high school teachers' attitudes or perceptions about SA. This can occur through prior level of knowledge and experience of SA (Wheeler, 2008).

Studies have also provided evidence that undergraduate and graduate students in colleges of agriculture agreed with SA beliefs but had only limited knowledge of SA topics except for graduate students in some graduate specializations who had good knowledge of SA practices (Sitienei & Morrish, 2014). For both students and agriculture teachers, research has established that interdisciplinary faculty collaboration in teaching SA, experiential learning, learning about societal needs, and context of learning can promote student and college faculty teaching and learning about SA (Agbaje et al., 2001; Borsari & Vidrine, 2005; Francis et al., 2009; Helms, 2014; Hilimire, 2016; Sameipour, 2017; Santone, 2003/2004). The above can take place when student experiential learning is combined with primary research involving college faculty and the farming community. Such pedagogical approach was found to facilitate faculty and students to develop systems thinking, critical thinking, higher-order learning, and interdisciplinarity (Ahmed et al., 2017).

One of the main challenges for agriculture teacher development and the teaching of SA among US high school students has been the lack of national curriculum standards for SA until recently (Spielmaker & Leising, 2013), despite recommendations by professional agencies to that effect (Borsari & Vidrine, 2005; Jacobsen et al., 2012; Lieblein, Østergaard, & Francis, 2004; National Council for Agricultural Education (NCAE), 1996; National Research Council (NRC), 1989; Parr, Trexler, Khanna, & Battisti, 2007; Spielmaker & Leising, 2013). The National Agricultural Literacy Outcomes (NALOS), which defined benchmarks related to agricultural literacy and academic achievement, had documented benchmarks for grade K2 to K12 for curriculum content broadly covering agriculture and the environment; plants and animals for food, fiber, and energy; food, health, and lifestyle; science, technology, engineering, and math (STEM); and culture, society, economy, and geography. Most benchmark areas have social science and science contents. The teaching-learning that NALOS emphasizes includes interdisciplinarity, transdisciplinarity, social learning, problem solving, and experiential learning. In general, the social reconstruction theory and framework, which focuses on learning opportunities being selected on the basis of undertaking learning on real problems, problems needing action, and teaching social values linked to society's goals for solving the problems, can guide education and the goals of SA. Such education is underlined by interdisciplinarity, experiential learning, problem solving, context of learning, and social learning (Helms, 2014; Spielmaker & Leising, 2013; Velten et al., 2015). Velten et al. (2015) developed an analytical framework for identifying the different conceptualizations of SA of key stakeholders involved in agricultural development based on goals, strategies, and fields of operations of the different actors. The researchers concluded that there is need for multiple conceptualizations of the stakeholders to be accommodated with a view to the development of common ground for actions in SA through building bridges (Wynne, 2002) connecting the different fields of knowledge.

The studies already mentioned did not investigate possible teacher differences regarding beliefs about SA or

perceptions of selected SA practices and the possible associations of these with the teaching of SA. Unlike teaching about SA, research on the attitudes of farmers and other agriculture stakeholders towards agriculture has revealed categories of the stakeholders beyond the dipolar groups of Beus and Dunlap (1990) subscribing to SA and CA in addition to farmers' neutrality about the SA paradigm (Abaidoo & Dickinson, 2009; De Olde, 2017; Herndl et al., 2010). Janker, Mann, & Rist (2018) criticize limitations of the dimensions of agriculture paradigms to the dipolar dimensions. Therefore, it is not known whether agriculture teachers diverge in paradigmatic positions beyond the SA/CA practice categories. It is also not known if this possible divergence can influence teaching about SA. The purpose of this study was to determine whether differences exist in teachers' mean ratings regarding beliefs about SA or perceptions of selected practices among teachers in the twelve states of the Midwest US who indicated agreement, disagreement, or being neutral to beliefs/perceptions about SA and whether these differences influenced the extent to which the teachers taught SA.

It is important to investigate diversity in the paradigmatic positions of teachers about agriculture because a number of studies have established a relationship between the paradigmatic positions in agriculture that one endorses and practices/behaviors in agriculture. This relationship includes farming practices adopted (Abaidoo & Dickinson, 2009; Allen & Bernhardt, 1995; Beus & Dunlap, 1991, 1994; Maini, De Rosa, & Vecchio, 2021; Rickson, Saffigna, & Sanders, 1999; Welsh & Rivers, 2011); affiliated agricultural organizations (Beus & Dunlap, 1991, 1994); professional field or agricultural course enrollment (Beus & Dunlap, 1992; Rasmussen & Kaltoft, 2003; motivation to teach SA (Helms, 2014; Hilimire, 2016; Sameipour, 2017; Williams & Wise, 1997); and knowledge and experience with SA practice (Rickson et al., 1999; Wheeler, 2008).

The paradigmatic position a teacher endorses about agriculture reflects his/her values about agriculture and can affect his/her cognition, behavior, and actions about SA practice (Williams & Dolliso, 1998). Beus and Dunlap (1991, 1994) indicated that examining the polar or relative positions of scores on the Alternative-Conventional Agriculture Paradigm (ACAP) scale could clarify the main points of agreement or disagreement between advocates of the SA/CA paradigms (and therefore variables of the ACAP scale emphasized or de-emphasized). Establishing if teacher SA/CA paradigms are associated with the teaching of SA can make a case for what can be taught, including the teaching of values in agriculture (Rasmussen & Kaltoft, 2003). This would be the case when the agricultural paradigm is determined by one's knowledge and experience of SA/CA (Wheeler, 2008) and vice versa. Teacher occupation of relative positions on the ACAP scale would mean that teachers would have different values about SA and preferences for the content of the agriculture curriculum and teaching-learning processes. This is all the more relevant given that values, motivation, and learning preferences also interact (Garton, Thompson, & Cono, 1997). Differential values about SA can affect whether critical problems such as the threat of irreversible ecological damage in agriculture can be addressed through education or not. Professional development programs that can meet teachers' needs about SA can enhance their conceptual understanding of SA and help them clarify conflicting values in learning about agriculture. This can help teachers adjust the curriculum and teaching methods to meet student learning needs in SA (Rasmussen & Kaltoft, 2003).

Although attitudinal variables only partially account for explanation of an individual's behavior with respect to beliefs about a phenomenon (Fishbein & Ajzen, 2003, 2010) such as SA/CA practices (Jackson-Smith & Buttel, 2003; Petrzelka & Korsching, 1996), few studies have established the role of structural variables in explaining teaching behaviors in SA compared to findings about farming practices and beliefs about SA. Also, some of the variables found to partially account for teaching behaviors in SA, such as gender and farm background, vary across studies (Agbaje et al., 2001; Muma, Martin, & Shelley, 2011). Because of the findings that teachers' beliefs about SA may or may not influence the teaching about SA (Muma et al., 2010), analysis of attitudinal differences about SA among teachers and whether this plays a role in teaching about SA could help in the search for potential structural variables that may account for teaching about SA beyond the two paradigms of agriculture. Also, potentially complex relationships among variables measuring teaching, attitudes, and constraints related to teaching SA (Straquadine, 1997; Udoto & Flowers, 2001) and their interactions may be uncovered. This analysis may lead to better modeling of research, extension, and education in SA.

Understanding teacher diversity in the paradigmatic positions in agriculture is a problem for society. To have any hope of preventing irreversible ecological changes in agriculture, land-grant university research, education, and extension programs need to be relevant and impact the practice of SA, and education programs will have to succeed in teaching values, knowledge, and skills to facilitate SA practice. To the best of our knowledge, no study has addressed the mentioned research problem using Likert measurements based on the six elements of the SA/CA paradigms in the ACAP scale (Beus & Dunlap, 1994) in the Midwest US states. Use of the ACAP scale meets the theoretical requirement for a scale to provide complete and diverse variables constituting meaningful

constructs (Nunnally, 1967). The Likert structure is best suited for attitudinal measures (Fishbein & Ajzen, 2003). The specific objectives of the study were to determine whether there is a difference in mean ratings:

1. of beliefs about SA among agriculture teachers who agreed, disagreed, or were neutral with respect to statements supporting beliefs regarding SA
2. of perceptions of selected SA practices among agriculture teachers who agreed, disagreed, or were neutral with respect to statements supporting beliefs about SA
3. of the extent to which teachers taught SA practices among teachers who agreed, disagreed, or were neutral with respect to statements about SA beliefs
4. of the extent to which teachers taught SA practices among teachers who agreed, disagreed, or were neutral with respect to statements about selected SA practices/topics
5. of the extent to which teachers used a variety of teaching methods to teach SA topics among teachers who agreed, disagreed, or were neutral with respect to statements supporting beliefs about SA
6. of the extent to which teachers used a variety of teaching methods to teach SA topics among teachers who agreed, disagreed, or were neutral with respect to statements about selected SA practices/topics
7. between and within groups of teachers who lived full-time on a farm for 0, 1-20, and 21-49 years
8. between and within groups of teachers who taught agriculture for 5, 6-15, 16-25, and over 25 years.

2. Methodology

2.1 Sample

The population comprised 2,904 high school agriculture teachers from the North Central Region states. Teachers responded to self-administered questionnaires with 5-point Likert scale items. Frame error was controlled by use of the most up to-date list of agriculture teachers available. Most of the agricultural education teachers taught agronomy and plant and soil sciences. Teachers were therefore assumed to be similar. A stratified random sample of 844 teachers stratified by agriculture teacher population in each state was drawn.

2.2 Data Collection

A descriptive design (McCracken, 1991) was adopted for the study. Dillman's (2000) Tailored Design Method was used. Only one reminder was sent to respondents to complete the questionnaires because of resource constraints. Overall, 239 useable questionnaires were returned (a 28% response rate). Non-response error was controlled by comparison of the early and late respondents. There was no significant statistical difference between the early and late responders on the main research variables. Thus, the findings are generalizable to agriculture teachers broadly (Lindner, Murphy, & Briers, 2001).

2.3 Variable Measurement

The instrument had 5-point Likert-type sub-scales on (1) teacher beliefs about sustainable agriculture practice, (2) teacher perceptions of selected sustainable agriculture practices/topics, (3) the extent to which teachers taught selected SA practices/topics, and (4) the extent to which teachers used a variety of teaching methods to teach selected topics in SA (Muma, Martin, & Shelley, 2011). The four subscales had 20, 21, 25, and 13 items, respectively. The first and second research variables had subscales with 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. The 20-item ACAP scale based on the six elements that distinguish respondent beliefs between SA and CA (Beus & Dunlap, 1991) was self-developed for the SA beliefs scale. The 20-item scale was adopted to suit it to attitudinal measures (Jackson-Smith & Buttel, 2003) and conditions in the research unit.

The third and fourth subscales had variables measured as: 1 = none, 2 = low extent, 3 = moderate extent, 4 = high extent, and 5 = very high extent. The demographic data from respondents used in the study provided information on the number of years teachers lived full-time on a farm and taught agriculture as structural variables. Instrument content and face validity were established by a panel of SA experts. Cronbach's coefficients alpha measuring inter-item consistency for the instrument ranged from .82 - .95 and were acceptable.

2.4 Data Analysis

Data for teacher beliefs about SA or perceptions of selected SA practices sub-scales were re-coded into agree, disagree, and neutral categories: 1-2.6 = disagree, 2.7-3.4 = neutral, 3.5-5.0 = agree. Data were analyzed with SPSS® using one-way analysis of variance (ANOVA), *F*-tests, and Bonferroni post-hoc tests. Non-directional (two-tailed) null hypotheses were evaluated using $\alpha = .05$ significance level.

3. Results

Levene's test showed equal variances of the mean ratings of the three groups (agree, disagree, neutral) on beliefs about SA. Mean ratings for the three groups of agriculture teachers on beliefs about SA were then compared by one-way ANOVA. A *F*-test found a significant difference ($p<.05$) among the three mean group ratings. Multiple comparisons for all pairwise combinations of the group mean ratings on SA beliefs were then conducted using the Bonferroni post-hoc procedure for the 20-item SA beliefs summated scale (Table 1).

Levene's test indicated lack of equality of variance in perceptions of selected SA practices among the three groups of teachers who agreed, disagreed, and were neutral with respect to beliefs about SA. Accordingly, the Brown-Forsythe test was employed, based on performing an ANOVA on a transformation of the response variable; the test statistic is the *F*-statistic resulting from an ordinary one-way ANOVA conducted on the absolute deviation of each observation from the median score. Comparisons of all possible pair-wise mean rating combinations were conducted using Tamhane's T2 post-hoc test, which is appropriate for the case of unequal variances, after the *F*-test indicated a significant difference among the group mean ratings on perceptions of selected SA practices in agriculture (Table 2).

Additionally, differences in mean ratings of perceptions of the extent to which teachers taught SA topics/practices were examined for the summated scale for agriculture teachers who were in the agree, disagree, and neutral categories of beliefs about SA. Levene's test for equality of variances showed equal variances among the three groups on the dependent teaching variable.

Table 1. Frequencies, standard deviations, and results of ANOVA tests for mean ratings of teacher beliefs about sustainable agriculture by beliefs response category

SA Beliefs Response Category (*n*)	*Mean*	*SD*	Source of Variation	*SS*	*DF*	*MS*	*F*	*p*
Disagree (8)	2.16[ab]	0.22	Between groups	30.936	2	15.468	287.091	<0.001***
Neutral (43)	3.23[a]	0.16	Within groups	12.500	232	0.054		
Agree (184)	3.82[b]	0.25						
Total (235)	3.66	0.43		43.435	234			

Note: SA = Sustainable agriculture; [ab] = means with the same letter are not statistically different ($p> .05$); *DF* = degrees of freedom; *SD* = standard deviation; *SS* = sums of squares; *MS* = mean squares; *** = *F* statistic significant at $p\leq.001$.

Mean ratings for the three groups were then compared by ANOVA using the *F*-test. No post-hoc multiple comparisons for pairwise differences in group means were assessed after the *F*-test indicated no statistically significant difference among the mean ratings on selected SA practices among teachers who agreed, disagreed, and were neutral on beliefs about SA. Results are summarized (Table 3).

Table 2. Frequencies, standard deviations, and results of ANOVA tests for mean ratings of teacher perceptions of selected sustainable agriculture practices/topics by perceptions response category

SA Perceptions Response Category (*n*)	*Mean*	*SD*	Source of Variation	*SS*	*DF*	*MS*	*F*	*p*
Disagree (8)	1.90[a]	0.60			2		114.809	<0.001***
Neutral (14)	3.14[b]	0.14			8.220			
Agree (209)	4.03[c]	0.34						
Total (231)	3.66	0.55						

Note: SA = Sustainable agriculture; [ab] = means with the same letter are not statistically different ($p> .05$); *DF* = degrees of freedom; *SD* = standard deviation; *SS* = sums of squares; *MS* = mean squares; *** = *F* statistic significant at $p\leq.001$.

Further, differences in the ratings of perceptions of the extent to which teachers taught SA topics/practices were

ascertained among teachers who agreed, disagreed, and were neutral on perceptions of selected sustainable agriculture practices/topics. Levene's test indicated equality of variance among the groups.

Table 3. Frequencies, standard deviations, and results of ANOVA tests of mean ratings of the extent to which teachers taught sustainable agriculture by SA beliefs response category

SA Beliefs Response Category (*n*)	*Mean*	*SD*	Source of Variation	*SS*	*DF*	*MS*	*F*	*p*
Disagree (8)	3.27 [a]	0.75	Between groups	0.361	2	0.180	0.330	0.719
Neutral (43)	3.09 [a]	0.69	Within groups	125.214	229	0.547		
Agree (181)	3.18 [a]	0.75						
Total (232)	3.17	0.74		125.575	231			

Note: SA= Sustainable agriculture; [ab] = means with the same letter are not statistically different ($p > .05$); *DF* = degrees of freedom; *SD* = standard deviation; *SS* = sums of squares; *MS* = mean squares; *** = *F* statistic significant at $p \leq .001$.

Mean ratings of perceptions of the extent to which agriculture teachers taught SA practices/topics for the three groups were compared by ANOVA using the *F*-test. Bonferroni multiple comparisons for the means were conducted after the *F*-test showed a statistically significant difference among the means. Results are presented (Table 4).

Table 4. Frequencies, standard deviations, and results of ANOVA tests for mean ratings of the extent to which teachers taught sustainable agriculture by perceptions of SA practices response category

SA Perceptions Response Category (*n*)	*Mean*	*SD*	Source of Variation	*SS*	*DF*	*MS*	*F*	*p*
Disagree (8)	3.26[ab]	0.76	Between groups	4.386	2	2.193	4.156	0.017*
Neutral (14)	2.65[a]	0.66	Within groups	120.306	228	0.528		
Agree (209)	3.22[b]	0.73						
Total (231)	3.19	0.74		124.692	230			

Note: SA = Sustainable agriculture; [ab] = means with the same letter are not statistically different ($p > .05$); *DF* = degrees of freedom; *SD* = standard deviation; *SS* = sums of squares; *MS* = mean squares; * = *F* statistic significant at $p \leq .05$.

A similar comparison of ratings of the extent to which teachers used a variety of methods to teach SA topics/practices was conducted by ANOVA for the three response categories of teachers on beliefs about SA as already described. There was no statistically significant difference in mean ratings of teacher perceptions of the extent to which teachers used different teaching methods to teach SA practices/topics. Results are presented (Table 5).

Table 5. Frequencies, standard deviations, and results of ANOVA for mean ratings of the extent to which teachers use different teaching methods by beliefs response category

SA Beliefs Response Category (*n*)	*Mean*	*SD*	Source of Variation	*SS*	*DF*	*MS*	*F*	*p*
Disagree (8)	2.93[a]	0.64	Between groups	0.224	2	0.112	0.204	0.815
Neutral (43)	2.99[a]	0.80	Within groups	125.016	228	0.548		
Agree (180)	3.06[a]	0.73						
Total (231)	3.04	0.74		125.240	230			

Note: SA = Sustainable agriculture; [ab] = means with the same letter are not statistically different ($p > .05$); *DF* = degrees of freedom; *SD* = standard deviation; *SS* = sums of squares; *MS* = mean squares; *** = *F* statistic significant at $p \leq .001$.

Additionally, comparison of ratings of the extent to which teachers used a variety of methods to teach SA topics/practices was performed using ANOVA for the three response categories of teachers on teacher perceptions about selected SA practices/topics as described earlier. There was no statistically significant difference in mean ratings of teacher perceptions of the extent to which teachers used different teaching methods to teach SA practices/topics. Results are presented (Table 6).

Table 6. Frequencies, standard deviations, and results of ANOVA tests for mean ratings of the extent to which teachers use different teaching methods by perceptions response category

SA Perceptions Response Category (*n*)	*Mean*	*SD*	Source of Variation	*SS*	*DF*	*MS*	*F*	*p*
Disagree (7)	3.08[a]	0.69	Between groups	0.004	2	0.002	0.003	0.997
Neutral (14)	3.05[a]	1.07	Within groups	124.457	225	0.553		
Agree (207)	3.06[a]	0.72						
Total (228)	3.06	0.74		124.461	227			

Note: SA = Sustainable agriculture; [ab] = means with the same letter are not statistically different ($p > .05$); *DF* = degrees of freedom; *SD* = standard deviation; *SS* = sums of squares; *MS* = mean squares; *** = *F* statistic significant at $p \leq .001$.

Post-hoc analyses using one-way ANOVA and Bonferroni multiple comparisons were performed to test the influence of teachers living on a farm full-time for different years, the number of years agriculture was taught, and teacher gender on the means of the research variables (Table 7, Table 8). Female agriculture teachers scored higher on beliefs about SA than did males and taught SA to a greater extent than did their male colleagues (results not shown).

Table 7. ANOVA Summary of sums of squares of beliefs, perceptions, extent of teaching, and teaching methods between and within groups of teachers who lived full-time on a farm for 0, 1-20, and 21-49 years

Dependent Variable	Source of Variation	DF	SS	MS	Significance
Beliefs about SA	Between Groups	2	0.44	0.15	0.49
	Within Groups	222	40.16	0.18	
	Total	225	40.60		
Perceptions about SA	Between Groups	2	0.21	0.07	0.88
	Within Groups	217	67.43	0.31	
	Total	220	67.65		
Extent of Teaching SA	Between Groups	2	7.44	2.48	0.00***
	Within Groups	218	114.80	0.53	
	Total	221	122.23		
Teaching Methods	Between Groups	2	9.15	3.05	0.00***
	Within Groups	224	111.28	0.50	
	Total	227	120.43		

Source: Own compilation

Note: SA = sustainable agriculture; DF = degrees of freedom; SS = sums of squares; MS = mean squares; *** = *F* statistic significant at $p < .001$

Table 8. ANOVA summary of sums of squares of beliefs, perceptions, extent of teaching, and teaching methods between and within groups of teachers who taught agriculture for 5, 6-15, 16-25, and over 25 years

Dependent Variable	Source of Variation	DF	SS	MS	Significance
Beliefs about SA	Between Groups	3	0.86	0.29	0.21
	Within Groups	227	42.17	0.19	
	Total	230	43.03		
Perceptions about SA	Between Groups	3	0.81	0.27	0.46
	Within Groups	221	69.56	0.32	
	Total	230	70.38		
Extent of Teaching SA	Between Groups	3	6.00	2.00	0.01**
	Within Groups	222	117.19	0.53	
	Total	225	123.18		
Teaching Methods	Between Groups	3	4.33	1.44	0.04*
	Within Groups	229	116.93	0.51	
	Total	232	121.26		

Note: SA = sustainable agriculture; DF = degrees of freedom; SS = sums of squares; MS = mean squares; * = *F* statistic significant at $p < .05$; ** = *F* statistic significant at $p < .01$.

4. Discussion

The majority of teachers are more likely not to differ on mean ratings of the beliefs variable. Teachers who disagreed on SA beliefs and those who were neutral to SA beliefs are more likely not to differ on their mean ratings on beliefs about SA. However, those who agreed and those who were neutral regarding statements supporting beliefs about SA are more likely to differ in their mean ratings of beliefs about SA. Additionally, teachers who agreed with statements supporting SA and those who disagreed are more likely to score similarly on their mean ratings of statements about SA. This is contrary to intuition. It is expected that either teachers who agreed with SA beliefs or those who disagreed could possibly each have mean ratings on SA beliefs closer to teachers who were neutral with respect to statements supporting SA beliefs but not the “agreed” and “disagreed” categories. The anomaly could be due to the small number of teachers who were in the disagree category. The agreed and disagreed SA beliefs mean ratings each were closer to the upper score range and lower score range for teachers who were neutral to SA beliefs, respectively.

When SA beliefs scores can be separated into the three categories, there is more likelihood that the difference in mean ratings of perceptions of teachers in the three categories of SA beliefs would be statistically significant. The overlapping of mean ratings for the three categories of SA beliefs underlines the overlapping nature of SA beliefs as stated in the literature. This is so since SA beliefs encompass more holistic values, which may be broken down into specific practices in which those embracing SA beliefs may be differentiated. Additionally, teachers in each of the three response categories on perceptions of selected SA practices or topics are more likely to differ significantly on mean ratings of that variable since perceptions of a phenomenon are specific. They are generally either embraced or not by individuals. Many more teachers and a bigger majority supported perceptions of SA practices than did teachers who disagreed or were neutral to statements about SA practices. The division in the perception scores into the three categories can be used to identify teacher development needs in SA curriculum including content, student interests, learning context, and teaching and evaluation approaches. It is therefore necessary to separate teacher perceptions of SA practice into categories for this purpose.

On the other hand, teachers in all three response categories of agree, disagree, or neutral on perceptions of selected SA practices are more likely to teach SA topics to the same extent, except for teachers in agree and neutral categories who are likely to differ significantly in the extent to which they would teach agriculture topics. However, there is no difference between all the categories of teachers who agreed, disagreed, or were neutral on beliefs about SA in the extent to which they taught SA topics. Finally, teachers in all three SA beliefs response categories and perceptions response categories are more likely not to differ on the extent to which they use a variety of different methods to teach SA. Beus and Dunlap’s (1991) conclusion that the relative positions of scores on the ACAP scale could clarify the main points of agreement or disagreement between advocates of the

SA/CA perspectives should be taken into account in analyzing teacher score differences. This is the case when knowledge and experience influence the agricultural paradigm of an individual.

The finding that teachers who were neutral on perceptions of selected SA topics/practices and those who disagreed on the same were more likely to teach SA topics to the same extent could be due to their close mean ratings on SA topics. This could also be the case because individuals should perceive specific components of a phenomenon such as SA/CA more specifically than the phenomenon itself (Beus & Dunlap, 1994; Fishbein & Ajzen, 2003, 2010) and therefore can teach the topics to a greater extent.

Additionally, the finding that those who agreed and those who disagreed about SA practices taught SA topics to the same extent is interesting for several reasons. The two groups are expected to diverge in the teaching of SA topics. Because selected practices taught are more specific, there could be poor correspondence between the beliefs and perceptions (Fishbein & Ajzen, 2003, 2010) of SA practices. Also, the construct "extent to which teachers taught SA" may not in theory and practice be complete in the elements that it conceptually represents. Further, unknown structural variables not controlled for in this study such as having lived on a farm or having knowledge and experience of agriculture in the past may account for the lack of difference in scores on the extent to which teachers taught SA among the beliefs response categories. The "extent to which teachers taught sustainable agriculture" may need further elaboration and testing for the above relationships. Because perceptions of SA practices are more specific, the significant difference in the extent to which teachers taught SA between teachers who agreed on the one hand and those who were neutral or disagreed on perceptions of SA practices on the other can be expected. The former category is not likely to use the same teaching-learning process for SA and professional training for promoting beliefs about SA compared to the latter category.

On the other hand, the results regarding teacher differences on beliefs about SA, perceptions of SA practices, the extent to which teachers taught SA, and the extent to which teachers used different methods to teach SA by beliefs/perceptions response categories may not be statistically plausible because the number of teachers who disagree with statements about SA on the variables ranged from 7-8. Further analysis of the differences in mean ratings about beliefs/perceptions regarding SA among the three teacher categories may be required using a larger sample size than was possible in this study. Finally, research on unknown structural variables that may influence teaching-learning processes about SA beyond paradigms of agriculture should continue.

5. Conclusion

This study has suggested that beliefs about SA may or may not influence the teaching of SA. Since professional development in SA can be used to influence knowledge in conceptualizing SA and paradigms of agriculture, it is important to identify teachers' needs including appropriate teaching innovations according to their beliefs and perceptions categories and address them in training. The need for systems teaching approach in SA in teacher professional development should be addressed by adoption of experiential learning, interdisciplinarity, social learning, and learning in appropriate contexts. Doing so will promote problem solving, critical thinking, and higher-order thinking skills, among others, particularly in satisfying teacher professional development in SA.

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References

Abaidoo, S., & Dickinson, H. (2009). Alternative and conventional agricultural paradigms: Evidence from farming in South Saskatchewan. *Rural Sociology 67*(1), 114-131. https://doi.org/10.1111/j.1549-0831.2002.tb00096.x

Agbaje, K. A., Martin, R. A., & Williams, D. L. (2001). Impact of sustainable agriculture on secondary school agricultural education teachers and programs in the North Central Region. *Journal of Agricultural Education, 42*(2), 38-45. https://doi.org/10.5032/jae.2001.02038

Agunga, R. A. (1995). What Ohio extension agents say about sustainable agriculture? *Journal of Sustainable Agriculture, 5*(3), 169-187. https://doi.org/10.1300/J064v05n03_13

Ahmed, S., Sclafani, A., Aquino, E., Kala, S., Barias, L., & Eeg, J. (2017). Building student capacity to lead sustainability transitions in the food system through farm-based authentic research modules in sustainability sciences (FARMS). *Elem Sci Anth, 5*(46), 1-17. https://doi.org/10.1525/elementa.239

Allen, J. C., & Bernhardt, K. (1995). Farming practices and adherence to an alternative-conventional agriculture

paradigm. *Rural Sociology, 60*(2), 297-309. https://doi.org/10.1111/j.1549-0831.1995.tb00574.x

Beus, C. E., & Dunlap, R. E. (1990). Conventional versus alternative agriculture: The paradigmatic roots of the debate. *Rural Sociology, 55*, 590-616. https://doi.org/10.1111/j.1549-0831.1990.tb00699.x

Beus, C. E., & Dunlap, R. E. (1991). Measuring adherence to alternative versus conventional agricultural paradigms: A proposed scale. *Rural Sociology, 56*, 432-460. https://doi.org/10.1111/j.1549-0831.1991.tb00442.x

Beus, C. E., & Dunlap, R. E. (1992). The alternative-conventional agriculture debate: Where do agricultural faculty stand? *Rural Sociology, 57*, 363-380. https://doi.org/10.1111/j.1549-0831.1992.tb00470.x

Beus, C. E., & Dunlap, R. E. (1994). Agricultural paradigms and the practice of agriculture. *Rural Sociology, 59*(4), 620-635. https://doi.org/10.1111/j.1549-0831.1992.tb00470.x

Borsari, B., & Vidrine, M. F. (2005). Undergraduate curricula in sustainability: An evaluation across borders. *Journal of Sustainable Agriculture, 25*(4), 93-112. https://doi.org/10.1300/J064v25n04_08

Conner, D., & Kolodinsky, J. (1997). Can you teach an old dog new tricks? An evaluation of extension training in sustainable agriculture. *Journal of Sustainable Agriculture, 10*(4), 5-20. https://doi.org/10.1300/J064v10n04_03

Constance, D. H. (2010). Sustainable agriculture in the United States: A critical examination of a contested process. *Sustainability 2*(1), 48-72. https://doi.org/10.3390/su2010048

De Olde, E. (2017). *Sustainability development of agriculture: Contribution of farm-level assessment tools* (unpublished PhD. Thesis). Wageningen Agricultural University, Netherlands. https://doi.org/10.18174/403334

Dillman, D. A. (2000). *Mail and Internet surveys: The Tailored Design Method*. New York: Wiley. https://doi.org/10.1177/003435520104400309

Fishbein, M., & Ajzen, I. (2003). Attitudes Towards Objects as Predictors of Single and Multiple Behavioral Criteria. In M. A. Hogg (Ed.), *Social psychology: Social Cognition and Perception* (Vol. 1, pp. 325-347). London, U.K.: Sage.

Fishbein, M., & Ajzen, I. (2010). *Predicting and Changing Behaviour: The Reasoned Action Approach*. New York: Psychology Press. https://doi.org/10.4324/9780203838020

Francis, C., King, J., Lieblein, G., Breland, T., Salomonsson, L. et al. (2009). Open-ended cases in agroecology: Farming and food systems in the Nordic Region and the US Midwest. *J Agr Educ Ext., 15*(4), 385-400. https://doi.org/10.1080/13892240903309645

Garton, B. L., Thompson, G. W., & Cono, J. (1997). Agriculture teachers and students: In concert or conflict? *Journal of Agricultural Education 38*(1), 38-45.

Helms, J. L. (2014). *Teaching and learning in sustainable agriculture curricula: A case study of faculty work as learning at a land grant university* (unpublished PhD. Dissertation). Virginia Polytechnic Institute and State University.

Herndl, C. G., Goodwin, J., Honeycutt, L., Wilson, G. et al. (2010). Talking sustainability: Identification and division in an Iowa Community. *Journal of Sustainable Agriculture, 35*(4), 436-461. https://doi.org/10.1080/10440046.2011.562068

Hilimire, K. (2016). Theory and practice of an interdisciplinary food systems curriculum. *NACTA J., 60*(2), 227-233.

Jackson-Smith, D. B., & Buttel, F. H. (2003). Social and ecological dimensions of the alternative-conventional agricultural paradigm scale. *Rural Sociology, 68*(4), 513-530. https://doi.org/10.1111/j.1549-0831.2003.tb00149.x

Jacobsen, K., Niewolny, K., Schroedr-Moreno, M., Van Horn, M., & Harmon, A. (2012). Sustainable agriculture undergraduate degree programmes: A land-grant university mission. *J Agric Food Syst Community Dev., 2*(3), 13-25. https://doi.org/10.5304/jafscd.2012.023.004

Janker, J., Mann, S., & Rist, S. (2018). What is sustainable agriculture? Critical analysis of the international political discourse. *Sustainability, 10*(12), 4707. https://doi.org/10.3390/su10124707

Kroma, M. M., & Flora, C. B. (2001). An assessment of SARE-funded farmer research on sustainable agriculture in the north central US. *Renewable Agriculture and Food Systems, 16*, 73-80.

https://doi.org/10.1017/S088918930000895X

Lieblein, G., Østergaard, E., & Francis, C. (2004). Becoming and agroecologist through action education. *International Journal of Agricultural Sustainability 2*(3), 1473-5903. https://doi.org/10.1080/14735903.2004.9684574

Lindner, J. R., Murphy, T. H., & Briers, G. E. (2001). The handling of non-response in agricultural education. *Proceedings of the 28th Annual National Agricultural Education Research Conference, 28,* 233-245, December 12, New Orleans, LA. https://doi.org/19.5032/jae.20011.04043

Madden, J. P. (1998). *The early years of LISA, and ACE programs: Reflections of the founding director - Phase 1; Western Region SARE.* Utah State University: Logan, UT, USA. https://doi.org/10.3390/su2010048

Maini, E., De Rosa, M., & Vecchio, Y. (2021). The role of education in the transition towards sustainable agriculture: A family farm learning perspective. *Sustainability, 13*(14), 8099. https://doi.org/10.3390/su13148099

Muma, M., Martin, R., & Shelley, M. (2011). Teacher beliefs and the extent to which sustainable agriculture is taught in high school. *Journal of Sustainable Agriculture, 35*(7), 804-822. https://doi.org/10.1080/10440046.2011.606494

Muma, M., Martin, R., Shelley, M., & Holmes, L. Jr. (2010). Sustainable agriculture: Teacher beliefs and topics taught, *Journal of Sustainable Agriculture*, *34*(4), 439-459. https://doi.org/10.1080/10440041003680312

National Council for Agricultural Education. (1996). *Applied environmental science: Introduction to environmental science*. Madison, WI: National FFA Foundation.

National Research Council. (1989). *Alternative agriculture*. Washington, DC: National Academy Press. https://doi.org/10.17226/1208

Nunnally, J. C. (1967). *Psychometric Theory*. New York: McGraw-Hill. https://doi.org/10.3102/00028312005003431

O'Sullivan, J. (2000). An evaluation of sustainable agriculture training in North Carolina. *Journal of Sustainable Agriculture, 16*(3), 39-52. https://doi.org/10.1300/J064v16n03_04

Park, T., & Lohr, L. (2007). Meeting the needs of organic famers: Benchmarking organizational performance of university extension. *Review of Agricultural Economics, 29*(1), 141-155. https://doi.org/10.2307/4624825

Parr, D. M., Trexler, C. J., Khanna, N. R., & Battisti, B. T. (2007). Designing sustainable agriculture education: Academics' suggestions for an undergraduate curriculum at a landgrant university. *Agriculture and Human Values, 24*(4), 523-533. https://doi.org/10.1007/s10460-007-9084-y

Paulson, D. D. (1995). Minnesota extension agents' knowledge and views of alternative agriculture. *American Journal of Sustainable Agriculture, 10*(3), 122-127.

Petrzelka, P., & Korsching, P. F. (1996). Farmers' attitudes and behaviour towards sustainable agriculture. *Journal of Environmental Education, 28*(1), 38-44. https://doi.org/10.1080/00958964.1996.9942814

Rassmussen, J., & Kaltoft, P. (2003). Alternative versus conventional attitudes in higher agricultural education. *Biological Agriculture and Horticulture, 20*, 347-363. https://doi.org/10.1080/01448765.2003.9754978

Rassmussen, P., & Kurki, A. (2007). *Evaluating impacts and outcomes of the western SARE research and education grants programme*. Utah State University.

Rickson, R. E., Saffigna, P., & Sanders, R. (1999). Farm work satisfaction and acceptance of sustainability goals by Australian Organic and Conventional Farmers. *Rural Sociology, 64*(2), 266-283. https://doi.org/10.1111/j.1549-0831.1999.tb00018.x

Sameipour, S. (2017). *Teachers' perceptions towards sustainable agriculture in an Ohio Science High School* (unpublished PhD. dissertation). Logan, UT: Ohio State University.

Santone, S. (2003/2004). Education for sustainability. *Educational Leadership, 61*(4), 60-63.

Sitienei, I., & Morrish, D. G. (2014). College students' knowledge of sustainable agriculture and its implications on the agricultural education curriculum. *NACTA Journal, 58*(1), 68-72. https://doi.org/10.5032/jae.2000.02019

Spielmaker, D. M., & Leising, J. G. (2013). *National Agricultural Literacy Outcomes.* Logan, UT: Utah State University, School of Applied Sciences & Technology. Retrieved from

http://agclassroom.org/teacher/matrix

Straquadine, G. S. (1997). An assessment of the agricultural education teachers' sustainable agriculture understanding and instructional materials use. *Paper Presented at Southern and Western Regions Agricultural Education Research Meeting*, April 4-5, Stillwater, OK.

Trout, S. K., Francis, C., & Barbuto Jr. (2005). Evaluation and perceived impacts of the North-Central Region SARE Grants, 1988-2002SARE Grants, 1988-2002. *Journal of Sustainable Agriculture, 27*(2), 117-137.

Udoto, M., & Flowers, J. F. (2001). Perceptions of agricultural education teachers toward sustainable agricultural practices. *Paper Presented at the 28th Annual Agricultural Education Research Conference* (pp. 433-444). New Orleans, LA.

Velten, S., Leventon, J., Jager, N., & Newig, J. (2015). What is sustainable agriculture? Critical analysis of the international political discourse. *Sustainability,* (7), 7833-7865. https://doi.org/10.3390/su7067833

Welsh, R., & Rivers, R. Y. (2011). Environmental management strategies in in agriculture. *Agriculture and Human Values, 28*, 297-302. https://doi.org/10.1007/s10460-010-9285-7

Wheeler, S. A. (2008). What influences agriculture professional's views towards agriculture? *Ecological Economics, 65*(1), 145-154. https://doi.org/10.1016/j.ecolecon.2007.05.014

Whent, L. S. (1997). Evaluation of the sustainable agriculture program. *Proceedings of the Southern and Western Regions Agricultural Education Research Meetings*, 245-251, April 4-5, Stillwater, OK.

Williams, D. L. (2000). Students' knowledge of and expected impact for sustainable agriculture. *Journal of Agricultural Education, 41*(2), 19-24. https://doi.org/10.5032/jae.2000.02019

Williams, D. L., & Dolliso, A. D. (1998). Rationale for research on including sustainable agriculture in the high school agricultural education curriculum. *Journal of Agricultural Education, 39*(3), 51-56. https://doi.org/10.5032/jae.1998.03051

Williams, D. L., & Wise, K. L. (1997). Perceptions of Iowa secondary school agricultural education teachers and students knowledge regarding sustainable agriculture. *Journal of Agricultural Education, 38*(2), 15-20.

Wynne, B. (2002). Risk and environment as legitimatory discourses of technology: Reflexivity inside out? *Curr. Sociol, 50*, 459-477. https://doi.org/10.1177/0011392102050003010