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Teacher Self-Efficacy as a Result of an Agriculture-based Renewable Energy Professional Development Workshop

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Abstract

Demand for a modern day workforce well versed in science, technology, engineering, and math (STEM) has been continuously increasing (Pinnell et al., 2013). It is of further concern that the United States is not producing an adequate number of skilled STEM graduates with the knowledge and skills necessary to address problems of the future (Beasley & Fischer, 2012). Since many renewable energy technologies are relatively new and often change (Faunce et al., 2013), it can be difficult for high school and community college instructors to stay abreast of new information in these fields (Zhao & Cziko, 2001). Bandura's (1997) self-efficacy theory served as the foundation for this study. The purpose of this study was to determine the effectiveness of a renewable energy professional development workshop for high school agriculture and science teachers in altering their science teaching efficacy and outcome expectancy beliefs. The Science Teaching Efficacy Beliefs Instrument (STEBI) (Riggs & Enoch, 1989) was adapted for this study to measure self-efficacy relative to teaching energy-related content. At the end of the workshop, teacher efficacy and outcome expectancy increased from the pre-test to the post-test, however long term increases in self-efficacy were deficient. Science-based professional development workshops have the potential to change in-service teacher behavior in the long-term. However, to secure long-term impacts on self-efficacy, it is recommended that bioenergy workshops offer follow-up support through an electronic community of practice.

***Keywords*:** self-efficacy, bioenergy, renewable energy, professional development

Introduction and Review of Literature

Demand for a modern day workforce well versed in science, technology, engineering, and math (STEM) has been continuously increasing (Pinnell et al., 2013). Fundamental STEM concepts are a naturally occurring component of the renewable and bioenergy sectors (Clase, Omolola, & Ha, 2014). Conversely, it is of concern that the United States is not producing an adequate number of skilled STEM graduates with the knowledge and skills necessary to address problems of the future (Beasley & Fischer, 2012). Moreover, challenges in the energy sector are among the largest facing our society as we move into the 21st century. Energy use in the United States is the highest among all nations, using 98 quadrillion BTUs of energy in 2010 (U.S. Energy Information Administration [EIA], 2011). The predominant sources used to provide this energy have been coal and natural gas for electricity, and oil for transportation fuels (EIA, 2011). Multiple social, economic, and environmental problems exist with each of these sources (National Research Council, 2010). Currently only 8% of U.S. energy comes from renewable sources, however that number is growing (EIA, 2011; EIA, 2012). Renewable energy sources include wind, solar, biofuels, hydroelectric, and anaerobic digestion.

Biofuels have recently received more attention from the U.S. government with the passage of the Energy Independence and Security Act of 2007 which calls for a transition from fossil fuels to renewable ones. Additionally, wind energy usage has also been increasing and currently powers approximately 3% of the U.S. electricity supply (EIA, 2012). Though anaerobic digestion is rare in the United States, it is part of the European Union's plan for transitioning to a biorenewable economy (Holm-Nielsen, Al Seadi, & Oleskowics-Popil, 2009).

In the move from a fossil-fuel based energy supply to a renewable one, new knowledge will be needed for careers in these fields (Jennings, 2009; National Research Council, 2009). Many of these jobs will likely require two-year degrees or technical training (Kandpal & Garg, 1998). To meet this global challenge, Kandpal and Garg (1998) proffered "renewable energy education…has to have the entire population as its target audience" (p. 394). As a result, this "rapid emergence of a global economy driven by science and technology has precipitated a crisis in the education systems of all nations" (Hestenes, 2013, p. 13). Kandpal and Broman (2014) recommended that renewable energy concepts must be introduced at the primary level and continue through all "formal and informal stages of education" (p. 312). At a time when bioenergy "education has a vital role to play in the development of a sustainable society" (Jennings, 2009, p. 436) researchers (Guest, Healion, & Hoyne, 2003; Healion et al., 2005) have identified a lack of quality in bioenergy education and a need to "increase efforts to educate the public" (Johnson, Edgar, & Edgar, 2013, p. 32). Since many renewable energy technologies are relatively new and often change (Faunce et al., 2013), it can be difficult for high school and community college instructors to stay abreast of new information in these fields (Zhao & Cziko, 2001). A focus on renewable energy educational efforts can assist to overcome this current problem in bioenergy education.

Agriculture increasingly intersects with the renewable energy sector through the production of raw materials used such as with biofuels or by sharing the land with state of the art capture methods such as wind turbines and solar panels (Beckman & Xiarchos, 2013). Although teaching agriculture education students concepts in renewable and bioenergy may be fairly new (Sallee, Edgar, & Johnson, 2013), Acker (2008) professed a need for curriculum at the primary, middle, and secondary school levels. However, the development of quality curriculum alone does not have the ability to impact student learning. Although much current professional development is focused upon school reform, researchers have indicated that high quality teacher professional development should be developed to enhance teachers' specific content and pedagogical knowledge (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; DiPaola & Hoy, 2014; Gusky & Sparks, 2004; Joyce & Showers, 2003; Nolan & Hoover, 2008; Peery, 2004).

Recently, numerous reform efforts have been targeted at science education (McNeill, Pimentel, & Strauss, 2013; Schneider, Krajcik, & Blumenfeld, 2005; Schneider, Krajcik, Marx, & Soloway, 2002). Most of these efforts focus primarily on a transition from teacher-centered instructional strategies to utilizing inquiry-based instruction (National Research Council, 1996). Inquiry-based instruction has significant advantages over traditional instructional strategies in the sciences. Gibson and Chase (2002) purported that students had a more favorable attitude toward science when taught through inquiry-based methods. Thoron and Burleson (2014) found that agricultural education students also responded positively to inquiry based instruction. Further, they recommended that "professional development should be provided for teachers in… inquiry-based instruction teaching methodology" (Thoron & Burleson, 2014, p. 73).

The convergence of renewable energy and agriculture, along with the need for agricultural education teachers who can, "…improve agricultural productivity efficiency and effectiveness in meeting our global food, fiber, and energy needs…" (Doerfert, 2011, p. 9) led to the creation of an agriculture-based renewable energy professional development workshop for high school and community college teachers. By using a consortium of industry professionals and university researchers, the workshop provided teachers with a "…professional learning community that support changed learning practices…" (Lieberman, 1995, p. 75). This renewable energy workshop implemented several strategies to promote teacher learning and increase perceived self-efficacy including experiential, team-based, and interdisciplinary professional development activities. Hands-on learning activities which supported inquiry-based instruction included basic energy principles, wind energy, anaerobic digestion, biomass and biodiesel production were developed and incorporated into an agricultural based renewable energy curriculum. Teachers were also provided with teaching materials and access to online curriculum modules. Since it is important that teachers should "know the subjects they teach and how to teach those subjects to students" (National Board for Professional Teaching Standards [NBPTS], 2014, p. 3), the question remains, can a renewable bioenergy workshop positively affect the confidence of secondary and community college agriculture and science teachers?

Purpose/Research Objectives

The purpose of this study was to determine the effectiveness of a renewable energy professional development workshop in altering the science teaching efficacy and outcome expectancy beliefs of science and agricultural education teachers. The objectives of the study were as follows:

1.) Describe the perceived levels of teacher efficacy before, immediately following, and nine months after the workshop.
2.) Analyze the differences between the perceived levels of teacher efficacy before, immediately following, and nine months after the workshop.
3.) Determine if differences between efficacies existed among demographic variables.

Theoretical Framework

Bandura's Social Cognitive Theory was used as the framework for this study with an emphasis on self-efficacy and outcome expectancy (Bandura, 2012). This theory posits, among other ideas, that a person's perception of one's individual self-efficacy is a determining factor of behavior (Bandura, 1982). Perceived self-efficacy has also been shown to determine how persistent individuals are in addressing a task when faced with challenges (Bandura, 1982; Bandura, 1989).

Bandura (1997) defined self-efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3). The beliefs which determine self-efficacy develop from four primary sources which include: mastery experiences, vicarious experiences, verbal persuasion, and psychological and affective states (Bandura, 1997). Mastery experiences have been identified as the most influential source of self-efficacy information. Successfully completing a task increases self-efficacy and provides an individual with a benchmark for future achievement. Vicarious experiences occur when an individual observes another completing a task. Bandura (1977) suggested that the more an observer identifies with an individual, the greater potential for impact on efficacy. Verbal persuasion generally occurs upon an individual receiving feedback from a supervisor or colleague. The impact of the persuasion is dependent upon the persuader's credibility and trustworthiness. Psychological and affective states include factors such as arousal, anxiety, stress, and fatigue. Each of these states may tend to impact self-efficacy either positively or negatively depending upon the activity or situation (Bandura, 1982).

Outcome expectancy has been defined as "a person's estimate that a given behavior will lead to certain outcomes" (Bandura, 1977, p. 193). It is a measure of the results that individuals expect will happen from an action or a set of actions. Bandura (1989) stated that outcome expectations are at least partially regulated by self-efficacy beliefs. The amount that outcome expectancy independently motivates the behaviors of individuals depends on the level of control that the individual has over the outcome. If an individual has complete control over an activity, self-efficacy has more of an effect than when there are outside factors affecting the outcome (Bandura, 1989).

Teacher self-efficacy finds its foundation in Rotter's (1954) social learning theory. This theory specifies impact in which reinforcement has upon behavior. "A reinforcement acts to strengthen an expectancy that a particular behavior or event will be followed by that reinforcement in the future" (Rotter, 1966, p. 2) which in turn develops personal expectancies. In Rotter's (1966) work regarding locus of control, he professed that individuals with a strong belief in the ability to control her/his personal destiny will

> *a) be more alert to those aspects of the environment which provide useful information for his future behavior; b) take steps to improve his environmental condition; c) place greater value on skill or achievement reinforcements and be generally more concerned with his ability, particularly his failures; and d) be resistive to subtle attempts to influence him (p. 25).*

Teacher self-efficacy was originally discovered through the inclusion of two items in an extensive questionnaire as part of a Rand study on teacher characteristics and student learning (Armor et al., 1976). Rand researchers were interested if teachers could control the reinforcement of their personal teaching actions. Using locus of control theory (Rotter, 1966) student motivation and learning were assumed to be "relevant reinforcers of teaching action"

(Henson, 2001, p. 4). Specifically, the Rand items were used to determine if teachers thought this control of reinforcement was internally or externally driven. Item one stated, “When it comes right down to it, a teacher really can’t do much because most of a student’s motivation and performance depends upon his or her home environment” (Tschannen-Mornan, Hoy, & Hoy, 1998, p. 204). Teachers who agreed with this statement tended to believe that environmental factors can overshadow any efforts made by the teacher and has been labeled general teaching efficacy. Rand item two stated, “If I try really hard, I can get through to even the most difficult or unmotivated students” (Tschannen-Mornan et al., 1998, p. 204). Teachers whose beliefs best aligned with this statement tended to believe that regardless of the external factors influencing student motivation and achievement, teachers have the ability to overcome it. This belief has been named personal teaching efficacy.

Building upon Rotter’s (1966) locus of control and the Rand (Armor et al., 1976) teacher efficacy study, Gibson and Dembo (1984) merged the theoretical foundations of Bandura’s work—self-efficacy and outcome efficacy—to develop a more reliable instrument to measure teacher self-efficacy. Gibson and Dembo (1984) determined that teachers with high levels of personal and general teaching efficacy maintained a stronger academic focus with students, were more efficient with use of on-task time, obtained higher levels of student engagement, and communicated higher expectations to their students than teachers with low levels of teacher efficacy.

Based upon Gibson and Dembo’s (1984) approach, additional subject matter efficacy belief instruments have been developed by researchers. These include the Science Teaching Efficacy Belief Instrument (STEBI) (Riggs & Enochs, 1990), Chemistry Teaching Efficacy Belief Instrument (CTEBI) (Rubeck & Enoch, 1991), and Mathematics Teaching Efficacy Belief Instrument (MTEBI) (Enochs, Smith, & Huinker, 2000). Riggs and Enochs’ (1990) STEBI determined two uncorrelated factors that make up science teacher self-efficacy—personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE). The two areas were found to be consistent with that of Gibson and Dembo (1984).

Research findings specific to the STEBI supported findings of other efficacy studies. Science teachers with higher levels of PSTE spent more time in preparing for science instruction and enjoyed it more (Waiters & Ginns, 1995). Teachers having higher levels of STOE implemented higher quality of teaching in science than those exhibiting lower levels of self-efficacy (Riggs, 1995).

Building upon Bandura’s (1977) definition of self-efficacy, Tschannen-Moran et al. (1998) defined teacher self-efficacy as “the teacher’s belief in his or her capability to organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context” (p. 233). Teachers with a strong sense of self-efficacy regarding the content that they are teaching tend to have better learning outcomes for their students. This is due to a belief that what they are teaching is important, worth the effort of teaching it, and that any obstacles encountered while teaching the material will be overcome (Tschannen-Moran & Hoy, 2001).

Methodology

The target population of this study was 18 high school and community college teachers from across the United States who self-selected to attend an agriculture-based energy workshop held at Iowa State University in Ames, Iowa. To address the research objectives, a survey to gauge teacher's perception of energy teaching abilities was developed by adapting the Science Teaching Efficacy Beliefs Instrument (STEBI) (Riggs & Enoch, 1989). The STEBI instrument developed by Enochs and Riggs (1990) has been shown to be effective at determining perceived teaching efficacy (Tschannen-Moran & Hoy, 2001; Woolfolk, 2007; Hoy & Hoy, 2009) which has been shown to lead to real learning outcomes for students (Dembo & Gibson, 1985). The survey consisted of 23 questions designed to elucidate two elements of self-efficacy as described by Bandura (2012). Thirteen questions measured PSTE and consisted of statements about the teachers' teaching abilities. The remaining ten questions assessed the STOE that measured the participants' expectations of future teaching outcomes. All 23 questions from the STEBI (Enochs & Riggs, 1990) were modified in one important way; items in the survey that originally used the word "science" were changed to "energy." For example, the item which stated "I am continually finding better ways to teach about science" was changed to "I am continually finding better ways to teach about energy."

The STEBI instrument has been shown to have strong internal reliability (Bleicher, 2004). Enochs and Riggs (1990) found the PSTE construct produced an alpha coefficient of (α = .90) and the STOE construct (α = .76). After the adjustment to the terminology for this study, the *post hoc* PSTE construct (α = .73) and STOE construct alpha (α = .79) were established at acceptable levels (George and Mallory, 2003).

The survey was conducted in two phases. In the first phase, teachers responded twice to each survey question at the end of the workshop using a post- then pre-method (Rockwell & Kohn, 1989). This method is designed to reduce the impact of "response shift bias" (Colosi & Dunifon, 2006. p. 2) which is a change that occurs in self-reported rankings after the acquisition of knowledge causing a shift in a person's perception of their previous opinions (Howard & Dailey, 1979). The second phase of the study consisted of the survey being conducted nine months after the workshop to gauge the affected long-term renewable energy teaching self-efficacy. This part of the survey was distributed to the participants using Dillman, Smyth, and Christian's (2008) procedure for electronic survey dissemination. The results of this study are limited to the convenience sample and should not be generalized beyond the population studied.

Workshop Participant Demographics

Eighteen high school science and agriculture teachers attended the four-day renewable energy workshop. The majority of workshop attendees held a current teaching license (*n* = 14, 87.5%) and were traditionally certified (*n* = 14, 100%). Participants' teaching experience ranged from one to 30 years with a mean of 14.85 years (*n* = 14). Table 1 contains a summary of the remaining demographic characteristics of the respondents.

Results

Objective One

The first objective was to describe the perceived levels of self-efficacy before, immediately following, and nine months after a renewable energy professional development workshop. Table 2 displays the number of responses, frequency, and percentages of the pre-, post-, and post-post responses to each item in the PSTE construct of the modified STEBI. Table 3 displays the number of responses, frequency, and percentages of pre-, post-, and post-post responses to each item in the STOE construct of the modified STEBI.

Table 1. Summary of Participants' Demographic Characteristics (n = 16).

	f	%
Subject Area Taught		
Agriculture	8	50.0
Science	5	31.3
Both Agriculture & Science	3	18.8
Energy Industry Experience		
Yes	4	25.0
No	12	75.0
Highest Degree Earned		
BA/BS	6	37.5
MA/MS	9	56.3
PhD/EdD	1	6.3
Teaching Level		
High School	14	87.5
Community College	4	25.0

Table 4 displays the renewable energy workshop participants mean PSTE and STOE values for the pre-, post-, and post-post responses. Seventeen of the eighteen workshop attendees completed the pre- and post-STEBI assessments. Fourteen of the seventeen respondents completed the post-post STEBI assessment for an 82.35% response rate. STEBI scores for PSTE and STOE all fell within the *unsure* category for pre-, post-, and post-post assessments. Items were scored using the following scale 1 = strongly disagree, 2 = disagree, 3 = unsure, 4 = agree, 5 = strongly agree.

Table 4. Mean PSTE and STOE values for renewable energy workshop participants.

STEBI Construct	Pre (*n* = 17) *M* ± *SD*	Post (*n* = 17) *M* ± *SD*	Post-Post (*n* = 14) *M* ± *SD*
Personal Science Teaching Efficacy	3.40 ± 0.44	3.81 ± 0.30	3.57 ± 0.35
Science Teaching Outcome Expectancy	3.57 ± 0.30	3.90 ± 0.43	3.52 ± 0.31

Objective Two

The second objective was to analyze the differences between the pre-, post- and post-post STEBI construct scores. A one-way repeated measures analysis of variance (ANOVA) was used for each construct. The factor was the time when the STEBI was administered and the variables were the measure of teacher efficacy and outcome expectancy. Each of the constructs was first submitted to Mauchly's Test of Sphericity. Both the results of the PSTE ($\chi^2(2) = 1.145$, $p = .564$) and the STOE ($\chi^2(2) = 1.521$, $p = .467$) were not found to violate the assumption of sphericity, (Girden, 1992). For the results from the ANOVA refer to table 5.

Table 2. Frequency and Percentages of Pre-, Post-, and Post-Post Responses by Item for the Personal Science Teaching Efficacy (PSTE) Construct of the Modified Science Teaching Efficacy Beliefs Instrument (STEBI) Following a Renewable Energy Workshop.

Personal Science Teaching Efficacy	Pre				Post				Post-Post			
		Str. Dis./ Disagree	Unsure	Agree/Str. Agree		Str. Dis./ Disagree	Unsure	Agree/Str. Agree		Str. Dis./ Disagree	Unsure	Agree/Str. Agree
	n	*f (%)*	*f (%)*	*f(%)*	*n*	*f(%)*	*f(%)*	*f(%)*	*n*	*f(%)*	*f(%)*	*f(%)*
I am continually finding better ways to teach about energy.	17	2(11.1)	5(29.4)	10(58.8)	17	0(0.0)	1(5.9)	16(94.1)	14	2(14.3)	1(7.1)	11(78.6)
Even when I try very hard, I don't teach about energy as well as I do most subjects.*	16	7(43.8)	3(18.8)	6(37.5)	15	6(4.0)	2(13.0)	7(46.7)	14	4(28.6)	3(21.4)	7(41.2)
I know the steps necessary to teach energy concepts effectively.	17	3(17.7)	9(52.9)	5(29.4)	15	0(0.0)	0(0.0)	15(100)	14	2(14.3)	4(28.6)	8(57.1)
I am not very effective in monitoring energy experiments.*	17	2(11.8)	7(41.2)	8(47.1)	17	3(17.6)	1(5.9)	11(64.7)	14	5(35.7)	4(28.6)	5(35.7)
I generally teach about energy ineffectively.*	17	3(17.7)	4(23.5)	10(58.8)	17	5(29.4)	1(5.9)	11(64.7)	14	2(14.3)	3(21.4)	9(64.3)
I understand energy concepts well enough to be effective teaching students about it.	17	1(5.9)	1(5.9)	15(88.2)	17	1(5.9)	0(0.0)	16(94.1)	14	1(7.1)	1(7.1)	12(85.7)
I find it difficult to explain to students why energy experiments work.	17	1(5.9)	3(17.7)	13(76.5)	17	2(11.8)	3(17.7)	12(70.6)	14	2(14.3)	3(21.4)	9(64.3)
I am typically able to answer students' energy questions.	17	4(23.5)	1(5.9)	12(70.6)	17	2(11.8)	0(0.0)	15(88.2)	14	2(14.3)	0(0.0)	12(85.8)

Table 2. Continued.

Personal Science Teaching Efficacy	Pre				Post				Post-Post			
		Str. Dis./ Disagree	Unsure	Agree/Str. Agree		Str. Dis./ Disagree	Unsure	Agree/Str. Agree		Str. Dis./ Disagree	Unsure	Agree/Str. Agree
	n	*f (%)*	*f (%)*	*f(%)*	*n*	*f(%)*	*f(%)*	*f(%)*	*n*	*f(%)*	*f(%)*	*f(%)*
I wonder if I have the necessary skills to teach about energy.*	17	5(29.4)	4(23.5)	8(47.1)	17	1(5.9)	1(5.9)	15(88.2)	14	3(21.4)	0(0.0)	11(78.6)
Given a choice, I would not invite the principal to evaluate my energy teaching.*	16	11(64.7)	1(5.9)	4(23.5)	16	15(93.8)	0(0.0)	1(6.3)	14	11(78.6)	2(14.3)	1(7.1)
When a student has difficulty understanding an energy concept, I am usually at a loss as to how to help the student understand it better.*	16	1(6.5)	2(12.5)	13(81.3)	15	0(0.0)	0(0.0)	15(100)	14	1(7.1)	0(0.0)	13(92.9)
When teaching about energy, I usually welcome student questions.*	16	1(6.3)	3(18.8)	12(75.0)	16	0(0.0)	0(0.0)	16(100)	14	1(7.1)	0(0.0)	13(92.9)

*Item was reverse coded.

Table 3. Frequency and Percentages of Pre-, Post-, and Post-Post Responses by Item to the Science Teaching Outcome Expectancy (STOE) Construct of the Modified Science Teaching Efficacy Beliefs Instrument (STEBI) Following a Renewable Energy Workshop.

	Pre				Post				Post-Post			
		Str. Dis./ Disagree	Unsure	Agree/ Str. Agree		Str. Dis./ Disagree	Unsure	Agree/ Str. Agree		Str. Dis./ Disagree	Unsure	Agree/ Str. Agree
Outcome Expectancy	*n*	*f(%)*	*f(%)*	*f(%)*	*n*	*f(%)*	*f(%)*	*f(%)*	*n*	*f(%)*	*f(%)*	*f(%)*
When a student understands energy better than usual; it is often because the teacher exerted a little extra effort.	17	1(5.9)	1(5.9)	15(88.2)	17	1(5.9)	0(0.0)	16(94.1)	14	0(0.0)	0(0.0)	14(100)
When the grades of students improve on the subject of energy, it is most often due to their teacher having found a more effective teaching approach.	17	0(0.0)	2(11.8)	15(88.2)	17	0(0.0)	1(5.9)	16(94.1)	14	0(0.0)	0(0.0)	14(100)
If students are underachieving in energy topics, it is most likely due to ineffective teaching.	17	7(41.2)	1(5.9)	9(52.9)	17	5(29.4)	1(5.9)	11(64.7)	14	3(21.4)	8(57.1)	3(21.4)
The inadequacy of a student's energy background can be overcome by good teaching.	17	1(5.9)	2(11.8)	14(82.4)	17	0(0.0)	2(11.8)	15(88.2)	14	2(14.3)	1(7.1)	11(78.6)
The low achievement on the topic of energy by some students cannot generally be blamed on their teachers.*	17	8(47.1)	5(29.4)	4(23.5)	17	7(41.2)	5(29.4)	5(29.4)	14	5(35.7)	8(57.1)	1(7.1)

Table 3. Continued.

Outcome Expectancy	Pre *n*	Pre Str. Dis./ Disagree *f(%)*	Pre Unsure *f(%)*	Pre Agree/ Str. Agree *f(%)*	Post *n*	Post Str. Dis./ Disagree *f(%)*	Post Unsure *f(%)*	Post Agree/ Str. Agree *f(%)*	Post-Post *n*	Post-Post Str. Dis./ Disagree *f(%)*	Post-Post Unsure *f(%)*	Post-Post Agree/ Str. Agree *f(%)*
When a low achieving child progresses in energy, it is usually due to extra attention given by the teacher.	17	0(0.0)	6(35.3)	11(64.7)	17	0(0.0)	4(23.5)	13(76.5)	14	0(0.0)	1(7.1)	13(92.9)
Increased effort in teaching about energy produces little change in some students' achievement in topics related to energy.*	17	3(17.7)	2(11.8)	12(70.6)	17	5(29.4)	0(0.0)	12(70.6)	14	5(35.7)	3(21.4)	6(42.9)
The teacher is generally responsible for the achievement of students in energy-related topics.	17	0(0.0)	9(52.9)	8(47.1)	17	0(0.0)	6(35.3)	11(64.7)	14	1(7.1)	5(35.7)	8(57.1)
Students' achievement in energy related topics is directly related to their teacher's effectiveness in energy teaching.	17	2(11.8)	1(5.9)	14(82.4)	17	1(5.9)	1(5.9)	15(88.2)	14	2(14.3)	2(14.3)	10(71.4)
I don't know what to do to turn students on to energy.	16	4(43.8)	6(37.5)	6(37.5)	16	1(6.3)	2(12.5)	13(81.3)	14	3(21.4)	3(21.4)	8(57.1)

*Item was reverse coded.

Table 5. ANOVA PSTE and STOE results.

	SS	*df*	*MS*	*F*	*p*
PSTE	1.483	2	.742	9.042	.001*
Error	2.132	26	.82		
STOE	1.184	2	.592	8.387	.002*
Error	1.836	26	.071		

*$p < .05$

Table 6 presents the results of the Bonferroni correction to the PSTE. This correction showed that there were statistically significant differences between initial and follow-up perceived efficacy levels ($p < 0.05$) in the PSTE construct.

The mean differences in the PSTE construct were analyzed using the Bonferroni correction. Estimated marginal means were used to calculate the mean difference due to different sample sizes between the groups. Table 6 shows a statistically significant increase between the STOE pre- and post-test (MD = 0.459) while the post-post test score was significantly lower than the post-test (MD = -0.261). No statistical difference was found between the pre- and post-post tests ($p = 1.000$).

Table 6. Post-Hoc Bonferroni for Personal Science Teaching Efficacy (PSTE).

	Mean Difference (MD)	*p* - value
Pre test / Post test	0.459	.001*
Pre test / Post-Post Test	0.198	.387
Post test / Post-Post Test	-0.261	.088

Note. The mean difference was calculated by subtracting the first test listed from the second test. *$p < .05$. The mean was based on estimated marginal means because of the different sample size.

The mean differences in the STOE construct were also analyzed using the Bonferroni correction. Estimated marginal means were used to calculate the mean difference due to different sample sizes between the groups. Table 7 shows a statistically significant increase between the STOE pre- and post-test (MD = 0.329) while the post-post test score showed a statistically significant difference from the post-test (MD = -0.379). However, no statistically significant difference was found between the pre- and post-post tests ($p = 1.000$).

Table 7. Post-Hoc Bonferroni for Science Teaching Outcome Expectancy (STOE).

	Mean Difference (MD)	*p* - value
Pre test / Post test	0.329	.005*
Pre test / Post-Post Test	-0.050	1.000
Post test / Post-Post Test	-0.379	.008*

Note. The mean difference was calculated by subtracting the first test listed from the second test. *$p < .05$. The mean was based on estimated marginal means because of the different sample size.

Objective Three

Objective three sought to determine if a difference between efficacies existed among demographic variables. A one-way repeated measures analysis of variance (ANOVA) and/or t-test was used to determine if there were statistical differences in the mean pre-, post-, and post-

post PSTE and STOE scores based on the following demographic categories: age, years of teaching experience, licensure type, subject area taught (agriculture, science, or both), whether or not the participant had bioenergy industry experience, highest degree earned, and teaching level (high school or community college). No statistically significant differences were found between any demographic categories' mean differences.

Conclusions, Implications, and Recommendations

When considering the findings from this research, it can be concluded that high quality, agriculture based, renewable energy workshops can increase teacher efficacy and outcome expectancy in the short-run. At the end of the workshop, teacher efficacy (PSTE) (MD = 0.459) and outcome expectancy (STOE) (MD = 0.329) increased from the pre-test to the post-test. Interestingly, no statistically significant differences were noticed between the pre- and post-post test for the PSTE or STOE constructs. This means that the long term efficacy effect upon workshop participants was negligible. STOE, on the other hand showed a statistically significant decrease in outcome expectancy from the post- to the post-post mean scores. This is a logical result since immediately following the workshop the teachers were enthusiastic about the material and had not encountered any obstacles in implementing it. After nine months, workshop participants had dealt with the normal time constraints, administrative non-support, and financial issues teachers frequently face implementing new curriculum.

An implication of this research is that science-based professional development workshops have the potential to change in-service teacher behavior in the long-term. However, long-term gains may be diminished, thus ongoing support is needed in order to maintain levels of efficacy. Bandura (1997) stated that four primary sources converge to determine self-efficacy: mastery experiences, vicarious experiences, verbal persuasion, and psychological and affective states. The workshop used experiential learning-based training within the bioenergy workshop to increase the content and pedagogical knowledge of the participants (Darling-Hammond et al., 2009; DiPaola & Hoy, 2014; Gusky & Sparks, 2004; Joyce & Showers, 2003; Nolan & Hoover, 2008; Peery, 2004), along with a peer supported, highly interactive structure which supported Bandura's (1997) sources of self-efficacy. It is not surprising that when the teachers left the training and moved into their own classroom, their peer supported mastery experiences waned while at the same time they lost the opportunity for vicarious experiences and verbal persuasion regarding the newly learned content. It is recommended that bioenergy workshops offer follow-up support through an electronic community of practice. Workshop organizers should help to facilitate this process to allow participants to share mastery experiences, attain vicarious experiences, provide verbal persuasion through peer feedback, and provide a sounding board to deal with psychological and affective states to enhance teacher efficacy. Further, it is recommended that teachers be encouraged to include workshop content and pedagogical acquisition into an individual professional development plan (IPDP) that is shared with her/his supervisor. By adding the integration of these newly acquired skills into the IPDP, the supervising administrator(s) can assist with formative supervision of the integration of the newly acquired skills which will provide verbal persuasion for the teacher in the local school district. This verbal persuasion by the teacher's supervisor will provide feedback to further enhance mastery experiences by the teacher, thus improving long-term self-efficacy in the renewable energy area.

The researchers have several recommendations based on the results of this study. Further longitudinal data should be collected measuring the teaching efficacy beliefs and outcome expectancies in order to access longer-term impacts of the workshop. Research should be conducted to determine if continued support of teachers after the conclusion of an agricultural-based renewable energy professional development workshop would be conducive to higher long-term efficacy and outcome expectancy from teachers.

The ultimate goal of increasing teacher self-efficacy is to increase student achievement. Since a highly skilled workforce is currently needed in the STEM field (Beasley & Fischer, 2012), highly skilled teachers are also needed. Teachers with a strong sense of self-efficacy believe that what they are teaching is important and will work hard to overcome the obstacles encountered while teaching (Tschannen-Moran & Hoy, 2001). The careful development of STEM-based workshops along with high quality follow-up support is critical in this worthy endeavor.

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