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The Influence of Agriscience Research SAEs on Perceived Self-Efficacy of 21st Century Skill Attainment

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Abstract

The purpose of this study was to determine the association between involvement in agriscience research SAEs and student's perceptions of 21st century skill attainment. Tenth through twelfth grade students enrolled at three purposely selected high schools were surveyed to assess their current level of perceived 21st century skills attainment. Selected 21st century skills were defined based upon the standards outlined by the P21 Framework Definitions for 21st Century Skills. According to the findings of this study, students who engaged in agriscience research SAEs expressed higher levels of perceived self-efficacy of 21st century skills in the following 21st century skill constructs: (a) critical thinking and problem solving, (b) communication and collaboration, (c) information literacy, (d) flexibility and adaptability, (e) initiative and self-direction, (f) productivity and accountability, and (g) leadership and responsibility. It is recommended that involvement in agriscience research SAEs be expanded in school-based agricultural education programs as a potential approach to support student development of 21st century skills.

Keywords: agriscience research SAEs, 21st century skills, self-efficacy

Introduction

Supervised Agricultural Experience (SAE) is an integral part of a comprehensive, school-based agricultural education program (Camp, Clarke, & Fallon, 2000; Cheek, Arrington, Carter, & Randell, 1994; Dyer & Williams, 1997; Phipps, Osborne, Dyer, & Ball, 2008; Talbert, Vaughn, Croom, & Lee, 2007). Through the process of experiential learning, SAE allows for the transfer of planned skills to real-world, agriculturally related work experiences (Baker, Robinson, & Kolb, 2012; Camp et al., 2000; Cheek et al., 1994; Phipps et al., 2008; Talbert et al., 2007). Those real-world experiences can be in the form of ownership/entrepreneurship, placement/internship, agriscience research, school-based enterprise, and service-learning types of student focused development (National Council for Agricultural Education, 2017).

Throughout recent decades, SAE involvement within school-based agricultural education (SBAE) has declined nationwide (Dyer & Osborne, 1995; Retallick & Martin, 2008; Steele, 1997). In the early 1990's, over 85% of agricultural education students in Iowa conducted SAEs, by 2005, that number dropped to only 56% (Retallick & Martin, 2008). More recently, an average of 46% of students surveyed in Florida, Indiana, Missouri, and Utah reported conducting an SAE (Lewis, Rayfield, & Moore, 2012). Although participation has declined, agricultural educators across the country agree that SAE is and should remain an integral component of school-based agricultural education (Camp et al., 2000; Wilson & Moore, 2007) due to a myriad of beneficial outcomes for students. SAE involvement is positively related to student achievement in agriscience classes

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(Cheek et al., 1994), prepares students for jobs in agriculture, develops agricultural knowledge, and instills positive work ethics (Dyer & Williams, 1997). With that in mind, if SAE is not part of a student's well-balanced agricultural education experience, career-related skill development could inherently be limited. However, extent literature does not sufficiently measure or draw out skill development attribution for SAE involvement, especially in the present environment of 21st century skill proliferation. Thus, skill development attributed to SAE engagement needs further exploration to create new dialogue and justification for SAE within SBAE.

Review of Literature

When the Smith-Hughes Act of 1917 was made law, it formalized programing in Career and Technical Education at the secondary level (Phipps et al., 2008). Included in the Smith-Hughes Act of 1917 was a requirement that all students in vocational agriculture (SBAE today) participate in supervised practice on a farm for at least six months per year (Phipps et al., 2008). Initially, those experiences could be either entrepreneurship/ownership, where students created an operation of their own on their family property, or placement, where students were employed by an agricultural entity (farm, business, or otherwise) (Phipps et al., 2008). Over subsequent decades, the term used to describe those work experiences changed numerous times until the contemporary term of Supervised Agricultural Experience was settled upon. Today, SAE areas have been expanded to include: (a) agriscience research, where students conduct research to discover new knowledge; (b) school-based enterprise, where students co-manage a business in a school setting; and (c) service-learning, where students engage in a self-directed and managed service-learning project (National Council for Agricultural Education, 2017).

In 1920, 48.6% of Americans lived in rural areas (Department of Commerce, 1922). Over the years, the number of American's living on farms has decreased significantly (US Department of Commerce, 2016), which directly affects the number of students who come from production farming backgrounds. Phipps et al. (2008), previously stated that 73% of students enrolled in agricultural education did not live on farms which decreases opportunities for production agriculture SAEs and on-farm placements due to a lack of agriculturally-related resources. SAE implementation is limited by students' diverse academic backgrounds and personal experiences and the lack of physical and financial resources of previous generations (Retallick, 2010). Addressing these challenges requires creativity from both the teacher and students as they view SAE through the lens of the 21st century (Retallick, 2010).

Perhaps one way to overcome the challenge of limited opportunities for SAE involvement can be through greater utilization of the expanded SAE areas such as agriscience research (Retallick, 2010). Agriscience research is an SAE area well-suited for integration into programs which may lack the agriculturally-based community resources necessary for entrepreneurship and placement SAEs. Furthermore, the utilization of agriscience research SAEs may be one way the SAE program can continue to find relevance and value with current agricultural education students.

According to the National Council for Agricultural Education (2015), there are three types of agriscience research SAEs: experimental, analytical, and invention. Experimental SAEs require a student to plan and implement an agricultural experiment utilizing the scientific process. Through an experimental SAE, students identify problems or questions, develop a hypothesis, test the hypothesis using scientific methods, verify prior research with results, and discover new knowledge (National Council for Agricultural Education, 2015). Foundationally, SAEs expose students to careers, allow them to develop specific industry-related skills, and provide students with a simulated work environment in which they can apply their academic and occupational skills (National Council for Agricultural Education, 2015). After agribusiness and management, agricultural careers in science, technology, engineering, and mathematics (STEM) are the second most in-demand agricultural career areas (Goecker, Smith, Fernandez, Ali, & Theller, 2015). Agricultural careers in STEM account for 27% of annual job openings in agriculture (Goecker et al., 2015). Presumably, the skills students develop through involvement in agriscience research SAEs would be transferable to the skills necessary for success in those careers.

Specifically, there is a need for researchers to identify what skills are required of students who wish to pursue STEM careers in agriculture. Many educators, administrators, and policy makers believe that American education needs to make a shift towards utilizing 21st century skills as educational outcomes (Trilling & Fadel, 2009). The Partnership for 21st Century Skills (2015) identified eleven 21st century skill areas, which are highlighted and defined in Table 1.

The need for 21st century skill development is supported empirically, suggesting those skills better prepare students for 21st century careers (Casner-Lotto, Barrington, & Wright, 2006; Rateau, Kaufman, & Cletzer, 2015). It is possible that 21st century skills can be developed in a number of different ways including through inquiry-based teaching, experiential learning activities, and involvement in FFA. Research indicates that inquiry-based teaching leads to the development of 21st century skills, including critical thinking (Haury, 1993; Mabie & Baker, 1996; Thoron & Myers, 2012; Wells et al., 2015), communication (Haury, 1993), and improved scientific literacy (Haury, 1993). Inquiry-based instructional methods closely align with the methods students engage in through experimental agriscience research SAEs (Wells et al., 2015). Mabie and Baker (1996) identified that experiential learning activities, which would include the activities of agriscience research SAEs, improved students' ability to observe, communicate, compare, relate, organize, and infer; all of which are essential components of inquiry.

Table 1

Definitions of 21st Century Skill Constructs

21st Century Skill Constructs	Definition
Creativity and Innovation	Can think creatively, work creatively with others, and implement innovations.
Critical Thinking and Problem Solving	Able to reason effectively, use systems thinking, make judgements and decisions, and solve problems.
Communication and Collaboration	Can communicate clearly in a wide range of contexts and for various purposes, listen effectively, and collaborate with others.
Information Literacy	Capable of accessing information efficiently and effectively, evaluating information critically, and using information accurately from a wide variety of sources.
Media Literacy	Able to analyze media messages and purposes. Can create media products.
Information and Communications Technology Literacy	Applies technology effectively. Uses technology as a tool to research, evaluate, and communicate information.
Flexibility and Adaptability	Able to adapt to change and be flexible, works effectively in a climate of ambiguity, and able to incorporate positive and critical feedback.
Initiative and Self-direction	Manages goals and time, able to work independently, and are self-directed lifelong learners.
Social and Cross-cultural Skills	Capable of interacting effectively with others and can work effectively in diverse teams.

Productivity and Accountability	Manages projects competently and produces high quality results.
Leadership and Responsibility	Guides and leads others and acts responsibly with the interests of the larger community in mind.

Note. Definitions from P21 Framework Definitions (Partnership for 21st Century Learning, 2015).

Finally, research supports the development of 21st century skills through FFA including the development of: (a) leadership skills (Lundry, Ramsey, Edwards, & Robinson, 2015; Rosch, Simonsen, & Velez, 2015; Townsend & Carter, 1983), (b) teamwork, cooperation, and collaboration (Lundry et al., 2015; Townsend & Carter, 1983), (c) creativity, (d) critical thinking and problem solving skills, (e) communication skills, (f) self-direction (Lundry et al., 2015), and (g) social skills (Carl D. Perkins Act, 2006; Lundry et al., 2015). Thus, if 21st century skills are developed through involvement in FFA, inquiry-based teaching, and experiential learning activities, perhaps those same skills could be attained through another component of a comprehensive, school-based agricultural education program, i.e. the agriscience research SAE.

The purpose of school-based agricultural education is to prepare students for careers in agriculture (National Council for Agricultural Education, 2012). In order to prepare students for 21st century careers, focus needs to also be directed at promoting the development of 21st century skills. Thus, there is a need to conduct research which identifies specific activities within a comprehensive, school-based agricultural education program which may enhance the development of 21st century skills.

Framework

This study was grounded in Kolb's Experiential Learning Theory, a four-stage continuous cycle that includes (a) concrete experience, (b) reflective observation, (c) abstract conceptualization, and (d) active experimentation (Kolb, 1984).

Experiential learning is a primary theoretical foundation of agricultural education (Cheek et al., 1994; Knobloch, 2003; Roberts, 2006; Stewart & Birkenholz, 1991). Because experiential learning is conceptually based on experiences, it is most commonly associated with SAEs in agricultural education (Cheek et al., 1994; Knobloch, 2003; Roberts, 2006). Experiential learning involves a direct learning event or experience, which requires active engagement in that learning event by the student (Clark, Threeton, & Ewing, 2010). However, Clark et al. (2010) believes that experiential learning, as it is currently being used within agricultural education, is not truly experiential learning. While utilizing experiential learning experiences, agricultural educators rarely provide opportunities for active experimentation or internal reflection (Osborne, 1994). In a study by Shoulders and Myers (2013), the most commonly omitted stage of experiential learning was active experimentation. The statement "learning by doing" is commonly utilized within agricultural education (Phipps et al., 2008), however, that practice only uses part of the experiential learning theory as it places the entire focus on concrete experiences, rather than on the holistic process of experiential learning, which should also include reflection and active experimentation (Clark et al., 2010). Experiential learning needs to be more than just involvement in the experience (Roberts, 2006). As applied to this study, this theory holds that if a secondary student were to participate in an agriscience research SAE, which requires a student to go through the four cycles of Kolb's Experiential Learning Theory, then they may develop 21st century skills. This is plausible, because prior research establishes that students create knowledge via experiential learning through Kolb's Experiential Learning Theory (Baker et al., 2012).

Within the model of Kolb's Experiential Learning Theory, the basis of this study is built on the assumption that students participating in agriscience research would attain and develop 21st century skills through their SAE, a form of supervised experiential learning. Within the context of a student's agriscience research SAE, first, a student would identify a problem and develop a hypothesis. As they test their hypothesis, the actual experiment manifests as the concrete experience. Because students are typically working on their own when conducting agriscience research SAEs, the 21st century skills of accountability, productivity, initiative, and self-direction are expressed through concrete experience. Within concrete experience, students build on prior knowledge and connect their learning to their personal interests, which requires creativity, innovation, and critical thinking. Next, the student would evaluate their results, which involves them in the reflective observation stage. While reflecting, they will confirm or deny their hypothesis, evaluate sources of error, and identify discrepancies and patterns in their data. Within reflective observation, a student must use critical thinking and problem-solving skills to reflect upon their experiment and experience. Movement into the abstract conceptualization stage would be evident as the student makes conclusions based upon their data. As students go through abstract conceptualization and they revise their ideas, they may practice information literacy as they seek information related to their research. Revision of their idea or the creation of new ideas from their results allows them to practice creative thinking and innovation. Changing one's ideas may require the student to be adaptable and flexible. Finally, as they apply their results and conclusions to real-world applications, the student would move into the active experimentation stage. Communication skills are developed as they share their findings and applications. They may also express leadership and responsibility as they apply what they have discovered to the world around them. In the case that the student starts to reinterpret their experience and develop their thoughts into new research ideas, they would move back into the concrete experience stage and begin the cycle again. Movement back into the concrete experience stage also leads to adaptability skills as students work to re-test their hypothesis and act on new ideas. This cycle could continue repeatedly throughout a student's high school SAE program.

Although the development of 21st century skills was a key component of this study, it was necessary to measure whether that skill development was recognized by the students. Thus, social cognitive theory was used to develop the instrument which measured perceived development of 21st century skills. Self-efficacy relates to one's belief in their ability to do something: complete a task, perform an action, etc. (Bandura, 1986). Students who experience success completing a task, tend to have higher self-efficacy (Schunk, 2012). Thus, in the context of this study, if a student successfully performs 21st century skills through the process of an agriscience research project, then they should have higher self-efficacy related to those skills.

Purpose and Objectives

The purpose of this descriptive, exploratory study was to determine if differences in perceived levels of 21st century skill development could be linked to student participation in agriscience research SAE. The selected 21st century skills included critical thinking and problem solving, creativity and innovation, communication and collaboration, information literacy, media literacy, ICT (information, communications, and technology) literacy, flexibility and adaptability, initiative and self-direction, social and cross-cultural skills, productivity and accountability, and leadership and responsibility (Table 1).

This study will be guided by the following objectives:

1. Describe student's perceptions of their current level of identified 21st century skills.
2. Describe the differences in perceptions of 21st century skills between students involved in agriscience research SAEs, those with any other SAE, and all other students.

Methods

This study included 599 10th-12th grade students enrolled at three purposely selected high schools whose school-based agricultural education programs included SAE instruction and utilized agriscience research SAEs. The researcher determined this through informal interviews with agricultural education instructors in the region. Survey design was utilized where students completed a paper questionnaire to acquire demographic information and their perceptions of their current level of attainment of 21st century skills. Data were collected during the second semester of the school year from three high schools that offered comprehensive school-based agricultural education programs in [state] and [state]. The school communities ranged in population from 150 to 5,500, were considered rural, and had a strong agricultural industry presence. A total of 328 surveys were returned (N = 328). Questionnaires were evaluated for completeness, response set, and other completion errors. In total 41(n) were removed, leading to a final usable sample of 287(N). Students unaccounted for at each school were either absent or declined to complete the instrument. Because generalizability was not the intent of this study, those potential subjects were not followed up to supply responses. Additionally, non-response error was not calculated or considered in accordance with the design of the study. Therefore, the results of this study are not generalizable beyond the sample discussed herein.

Instrument

The 21st Century Skills Perceived Self-Efficacy Survey was created for this study using the guiding principles of Bandura (2006) and the P21 Framework Definitions for 21st Century Skills (Partnership for 21st Century Learning, 2015). The instrument was created using all eleven 21st century skill categories, as defined by the Partnership for 21st Century Learning (2015). The questions on the instrument were developed directly from the benchmarks and standards of each specific 21st century skill category as listed in the P21 Framework Definitions. The standards and benchmarks were reworded to fit Bandura's recommended language for constructing self-efficacy scales, which required the questions to be worded in a "can do" statement to measure perceived capability versus self-worth (Bandura, 2006). Pajares, Hartley, & Valiante recommend that a response scale of 0-100 be utilized in self-efficacy instruments because the larger scale is a stronger predictor of performance than five-point interval scales (as cited in Bandura, 2006, p. 312). Smaller scales are less sensitive and reliable because people tend to avoid the extreme ends of the scale, which make it difficult to identify any differences among subjects (Bandura, 2006). Further, a 0-100 point scale eliminates the discrete points of a traditional Likert-type scale, therefore allowing for the findings to be interpreted as a continuous measure (Bandura, 2006).

The 21st Century Skills Perceived Self-Efficacy Survey consisted of 87 questions aimed at measuring the strength of students' self-efficacy beliefs related to specific 21st century skills on a 100-point scale. The 100-point scale used descriptors at 0 (cannot do at all), 50 (moderately certain can do), and 100 (highly certain can do). Respondents were asked to indicate their current, perceived ability by writing a number between 0-100 in a column next to the statement. Eleven 21st century skill categories were included in the instrument including critical thinking and problem solving (8 questions in construct), communication and collaboration (12 questions in construct), creativity and innovation (10 questions in construct), information literacy (7 questions in construct), media literacy (7 questions in construct), ICT (information, communications, and technology) literacy (3 questions in construct), flexibility and adaptability (9 questions in construct), initiative and self-direction (8 questions in construct), social and cross-cultural skills (6 questions in construct), productivity and accountability (12 questions in construct), and leadership and responsibility (5 questions in construct).

The instrument was evaluated for face and content validity to ensure the questions appeared effective and would accurately measure what they intended to measure. A panel of experts within teacher education and school-based agricultural education evaluated the instrument for wording and readability (n = 3). Adjustments to the instrument were made, including eliminating and rewording of some of the questions, based on their recommendations. To ensure reliability, the instrument was piloted with a group of 34 students similar to the identified population for this study. Reliability for each construct generated the following Cronbach's alpha scores estimating the internal reliability for each construct: critical thinking and problem solving (.87), communication and collaboration (.88), creativity and innovation (.89), information literacy (.79), media literacy (.82), ICT literacy (.80), flexibility and adaptability (.83), initiative and self-direction (.85), social and cross-cultural skills (.79), productivity and accountability (.88), and leadership and responsibility (.83). The researchers established a coefficient of stability threshold for test-retest reliability of .70, a priori (Ary, Jacobs, Razavieh, & Sorensen, 2006). The original drafted instrument included 107 items. Following reliability analysis, 87(n) unique items were retained.

The final section of the instrument included 18 demographic questions and statements. Items specific to the student included: current grade, gender, enrollment in agricultural education or not, SAE involvement or not, and agriscience research involvement or not. Participants were also asked to answer questions regarding their type of SAE, years of experience in agriscience research and the number of completed projects, and involvement in FFA awards related to agriscience research, such as the agriscience fair, proficiency awards, and Star in Agriscience awards. The inclusion of contextual and demographic variables was supported by previous research on SAE within agricultural education.

Data Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) software version 21. The responses to all the questions within each construct were averaged and thus, a students' total perceived self-efficacy was reported by construct, not by each individual question. A mean of 70-100 confidence indicated a high level of perceived self-efficacy. A mean of 40-69.99 indicated a moderate level of self-efficacy, whereas a mean of 0-39.99 indicated low self-efficacy related to 21st century skills.

Descriptive statistics were run to analyze independent and dependent variables, including means and standard deviations. Group means for objective two were analyzed using a one-factor between subjects ANOVA where students self-identified themselves into different groups: students who participated in agriscience research SAEs, those who participated in other SAEs, and those who did not participate in SAEs. Eight students reported having agriscience research SAEs in addition to at least one other type of SAE. Those eight students were combined with the 16 students that only maintained agriscience research SAEs to create the agriscience research SAE group (n = 24). All other students that indicated having an SAE made up the second group (n = 89). The third group was made up of students that had taken agricultural education courses and did not have SAEs, as well as students that had never been enrolled in any agricultural education courses. Based on the theoretical framework of this study, it is justified to combine students without SAEs with those that have never been enrolled in agricultural education because ideologically, comprehensive agricultural education cannot exist without SAEs. Thus, students that have been enrolled in agricultural education courses but do not maintain SAEs will theoretically not have the opportunity to develop the same skills as those that do maintain SAEs, and thus they were combined with the non-Ag Ed students.

Description of Respondents

Descriptive statistics were used to analyze demographic information of the respondents. Characteristics of the sample are found in Table 2. The greatest number of respondents were sophomores (36.9%, *n* = 106) whereas the fewest represented were juniors (27.5%, *n* = 79). The distribution of the sexes for the sample included more females (50.5%, *n* = 145) than males (47.7%, *n* = 137). A majority of respondents had enrolled in agricultural education at some point during high school (56.4%, *n* = 162) compared to respondents who had not enrolled in agricultural education before (42.2%, *n* = 121). Of the students that indicated they had a Supervised Agricultural Experience (SAE), the majority of respondents had entrepreneurship SAEs (23.9%, *n* = 27). Other SAE areas that had high participation were placement SAEs (23%, *n* = 26) and agriscience research SAEs (14.2%, *n* = 16).

Table 2

*Demographic Characteristics of Participating Students (*N = *287*)

Variable	*n*	%
Student Class Rank		
Sophomore	106	36.9
Junior	79	27.5
Senior	95	33.1
Missing	7	2.4
Sex		
Female	145	50.5
Male	137	47.7
Other	2	0.7
Missing	3	1.0
Enrolled in Ag Ed		
Yes	162	56.4
No	121	42.2
Missing	3	1.0
SAE Type		
Entrepreneurship	27	9.4
Placement	26	9.1
Research	16	5.6
Exploratory	4	1.4
Other	24	8.4
N/A	171	59.6
Missing	3	1.0
Combined SAE	16	5.4

Findings

Objective one was to describe student's perceptions of their current level of identified 21st century skills. For all the respondents, the sample means for each 21st century skill construct indicates, on average, a high confidence in their abilities within each skill area. The means for each

21st century skill construct fell within a high level of perceived self-efficacy, with the lowest mean being the communication and collaboration construct (*M* = 72.19, *SD* = 15.54) to the highest mean being ICT literacy (*M* = 80.11, *SD* = 14.09) for the entire present sample (*N* = 287). The means for each construct and group are found in Table 3.

Table 3

Current Level of Identified 21st Century Skills by Group

	All (*n* = 287)		No SAE (*n* = 171)		Other SAE (*n* = 89)		Agriscience SAE (*n* = 24)	
21st Century Skill Construct	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Critical Thinking and Problem Solving	75.76	14.93	75.37	15.89	74.42	13.66	85.36	10.59
Communication and Collaboration	72.19	15.54	70.97	16.60	72.44	13.25	80.05	14.13
Creativity and Innovation	74.02	14.81	73.08	16.17	74.54	12.50	79.00	11.52
Information Literacy	73.31	15.51	71.69	16.96	74.50	12.86	80.80	11.06
Media Literacy	73.42	15.85	72.60	16.60	73.48	15.01	79.38	12.63
ICT Literacy	80.11	17.07	79.80	18.03	80.32	15.61	81.60	15.97
Flexibility and Adaptability	73.65	14.72	72.68	15.41	73.17	13.72	81.97	11.00
Initiative and Self-direction	77.04	15.27	76.28	15.96	76.47	14.00	84.40	13.94
Productivity and Accountability	78.72	14.76	77.73	16.17	78.83	11.98	85.40	12.81
Leadership and Responsibility	73.20	17.34	71.83	18.38	73.31	16.11	81.96	12.22
Social and Cross-cultural Skills	78.17	14.09	77.74	15.29	77.61	12.49	83.78	10.42

Note. Perceived self-efficacy used a 100-point scale using descriptors at 0 (cannot do at all), 50 (moderately certain can do), and 100 (highly certain can do). Range based off averaged construct means.

The respondents were broken into groups specific to their involvement in SAEs. The three additional groups were (a) No SAE (*n* = 171), (b) Other SAE (*n* = 89), and (c) Agriscience SAE (*n* = 24). Respondents who indicated they were not enrolled in agricultural education or were enrolled in agricultural education but did not maintain an SAE were placed in the "No SAE" group. Students that indicated they participated in any other SAE area other than agriscience research were placed in the "Other SAE" group. Any respondent who participated in agriscience research SAEs, whether combined with another SAE area or not, were placed in the "Agriscience SAE" group.

Objective two was to describe the differences in perceptions of 21st century skills between students in agriscience research SAEs, those with any other SAE, and all other students. The students were broken into three groups based on their involvement in agriscience research SAEs (n = 24), involvement in other SAEs (n = 89), and no involvement in SAEs or agricultural education (n = 171). A one-way ANOVA was conducted to determine if the means of perceived self-efficacy of 21st century skills differed between students depending on their involvement in agriscience research SAEs, SAEs, or none of the above. Assumptions for a one-way ANOVA were tested according to recommendations by Field (2013) and were met. Table 4 contains the results of the ANOVA tests. The results indicated that the difference between means of perceived self-efficacy were significantly different for all the 21st century skills constructs except creativity, media literacy, ICT literacy, and social/cross-cultural skills between the three groups (agriscience research SAEs, SAEs, and no SAE/no Ag Ed). In terms of practical significance (Table 4), the magnitude of omega-squared for all values suggests a small association between the involvement in agriscience research SAEs and perceived self-efficacy of 21st century skills. The magnitude of omega-squared was interpreted using Cohen's reference values (1988). The computed value indicates that between 1% and 2% of variability in perceived self-efficacy of 21st century skills can be attributed to involvement in agriscience research SAEs.

Given that the omnibus F test was significant, a post-hoc analysis was needed to determine which groups in particular showed significant differences between their means. All possible pairwise comparisons were made using the Tukey procedure with a familywise significance level of .05. The post-hoc procedure revealed that nine significant contrasts existed ($p < .05$). The significant contrasts are indicated in Table 4.

Table 4

Association Between 21st Century Skills Constructs and Involvement in Agriscience Research SAEs (N = 287)

21st Century Skill Construct	*df*	*F*	ω^2	*P*
Critical Thinking/Problem Solving	2, 284	3.56***	.02	.03
Communication/Collaboration	2, 284	3.67**	.02	.03
Creativity/Innovation	2, 284	1.75	.01	.18
Information Literacy	2, 284	4.03**	.02	.02
Media Literacy	2, 284	1.93	.01	.15
ICT Literacy	2, 284	0.13	-.01	.88
Flexibility/Adaptability	2, 284	4.33***	.02	.01
Initiative/Self Direction	2, 284	3.10**	.01	.05
Productivity/Accountability	2, 284	2.88**	.01	.06
Leadership/Responsibility	2, 284	3.67**	.02	.03
Social and Cross-cultural Skills	2, 284	2.10	.02	.12

Note. * indicates a significant pairwise comparison of means of perceived 21st century skills constructs between students with agriscience research SAEs and other SAEs. ** indicates a significant pairwise comparison of means of perceived 21st century skills constructs between students with agriscience research SAEs and no SAE. *** indicates a significant pairwise comparison for both comparisons.

Conclusion/Recommendations/Implications

We conclude agriscience research SAEs can have an influence on perceived self-efficacy of 21st century skills attainment. However, a limitation of this study is that the results are not generalizable across the entire population of agricultural education students in the country due to the exploratory nature of this study and the selected methods with which it was conducted. Nonetheless, the results of this study do indicate that there may be a small association between involvement in agriscience research SAEs and the development of 21st century skills. Further, it is recognized that self-efficacy does not equal ability, and thus does not give a clear indication of skill development. However, the purpose of using perceived self-efficacy in this study was to explore the connection between 21st century skills and agriscience research SAEs. Future studies should be conducted to explore skill development as it relates to involvement in agriscience research SAEs.

The data indicated there was a significant difference in perceived self-efficacy of seven 21st century skills constructs between students who had participated in agriscience research SAEs compared to students that maintained other SAEs and those who either did not have an SAE or had not enrolled in any agricultural education courses. Though the effect size was small, a difference does exist in the perceived self-efficacy of 21st century skills of students who participated in agriscience research SAEs and those who did not. Plausibly, students do attain 21st century skills by moving through the four-stage cycle of Kolb's Experiential Learning Theory. As it relates to the theoretical framework for this study, it is likely that students expressed various 21st century skills while participating in their agriscience research SAEs, which moved them through the four stages of experiential learning. As students successfully expressed those 21st century skills, they gained confidence in their abilities, and thus increased their perceived self-efficacy related to those skills. While it is proposed that students develop 21st century skills throughout their involvement in agriscience research SAEs, it is possible that a lack of deliberate reflection and identification of what was learned could impede the development of those skills within the phases of the Experiential Learning model. Further research is recommended related to the deliberate instructional intent of skill development to better test the development of skills within the framework of Kolb's Experiential Learning Theory.

Due to the small effect size, the results of this study are certainly not definitive. Prior research indicates that many different factors and experiences contribute to the development of 21st century skills in high school students. Some of those factors include involvement in FFA experiences (Carl D. Perkins Act, 2006; Lundry et al., 2015; Rosch et al., 2015; Townsend & Carter, 1983), engagement in experiential learning activities (Mabie & Baker, 1996), and participation in inquiry-based learning experiences (Haury, 1993; Mabie & Baker, 1996; Thoron & Myers, 2012; Wells et al., 2015). In the broad scope of preparing students for future careers in agriculture, the likelihood of finding a one-size fits all solution related to the development of 21st century skills is unlikely. However, the significantly different means between some of the 21st century skill areas does indicate that a possible connection exists between the development of 21st century skills and involvement in experiential learning activities, such as agriscience research SAEs. Therefore, the utilization of agriscience research SAEs and similarly structured experiential learning activities in school-based agricultural education programs may lead to the development of 21st century skills and more career-ready students.

Retallick (2010) purported that creative approaches from both the teacher and students is a way to overcome the challenges related to SAE involvement in the 21st century. One innovative solution to the decline in SAE involvement due to changing demographics and a lack of resources available to teachers and students (Retallick, 2010) may be to utilize agriscience research SAEs, which potentially lead to the development of essential 21st century skills. Due to the flexible nature of agriscience research SAEs, paired with the fact that many agriscience research projects can be conducted with limited inputs and resources, it is logical that implementation of these SAEs should be expanded to more schools so that more students can benefit from involvement in SAE.

In order to achieve the goals of engaging students in the development of 21st century skills and maintaining involvement in SAE, current agricultural education should be encouraged to utilize agriscience research SAEs. Recommendations based on this study include the intentional use of Kolb's Experiential Learning Theory as students engage in agriscience research SAEs and related experiences. In order to effectively assist students in the development of 21st century skills, efforts should be made to ensure students move completely through the four cycles of Kolb's Experiential Learning Theory as they participate in activities such as agriscience research SAEs. Teachers may need to challenge students to fully complete all four cycles, rather than stop after the completion of the concrete experience or other parts of the four-cycle model. Further, as teachers guide their students through the components of an agriscience research project, Bandura's Social Cognitive Theory (1986) indicates that engagement in a particular skill may increase student's self-efficacy. Without teacher encouraged reflection, students may not recognize the 21st century skills they develop through agricultural education activities. Thus, teachers are encouraged to consistently remind students to deliberately reflect upon and recognize the skills they practice and express through engagement in agriscience research SAEs and related activities. Tools and guides linking 21st century skills to aspects of an agriscience research SAE should be developed to bring this to life.

We recommend that further research be conducted regarding agriscience research SAEs and their application within school-based agricultural education. Though perceived self-efficacy suited the exploratory purpose of this study, other methods are necessary for future studies. We determined it was not feasible to create an instrument that quantitively measured all 21st century skill constructs together. Further, that instrument would have been unnecessary for a descriptive, exploratory study. Consequently, perceived self-efficacy was chosen because it could be used to measure the eleven different 21st century skill constructs at one time. However, we recognize that students' perceptions of their abilities do not necessarily measure their actual attainment of specific skills accurately. For example, a student's perceived critical thinking ability may not necessarily match their score gathered via an instrument used for the purpose of measuring critical thinking ability. This point does highlight the need for further research, specifically regarding the actual attainment of identified skills, not just student perceptions of skills. Future studies focused on the actual development of 21st century skills, such as critical thinking, are encouraged. This could be done using experimental or quasi-experimental methods or by utilizing longitudinal inquiry to follow students' development within SAE overtime.

Certainly, other dependent variables could have been chosen for this study. However, 21st century skills were selected because of their communicative value in today's educational climate and the continued need to justify the value of SBAE within our educational system. It is important for agricultural educators to be able to communicate the value of agricultural education to stakeholders in terms that are transferable across disciplines. The term "21st century skills" is readily understood across academic disciplines and thus was selected for this study. Nonetheless, future studies are encouraged and needed to measure the effect of agriscience research SAE involvement on other educational outcomes.

The instrument used in this study has the potential to be used for further inquiry focused on investigating 21st century skills. However, the present instrument needs further application and validation to allow for more in-depth study, if self-efficacy is a goal of the inquiry.

As the data were analyzed, we noticed consistent ambiguity related to the various definitions associated with agriscience research projects, agriscience research SAEs, and the National Agriscience Fair. It is recommended that leadership in The Council and The National FFA Organization direct attention to these definitions and work to create clear, unified definitions that are readily available and understood by all agricultural education stakeholders.

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