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Science Citizenship through Secondary Agricultural Education

Abstract

Global society has major scientific challenges to solve over the coming decades including climate change and food insecurity. Considering school-based agricultural education can play an important role in developing scientifically literate and civically engaged citizens to help address these challenges, this study sought to describe and compare Pennsylvania agricultural education students' science literacy, civic engagement, and science citizenship. In addition, the purpose of this study was to determine which variables of science literacy and civic engagement best predicted students' science citizenship. Using a descriptive-correlational research design, the study utilized a questionnaire adapted from three existing instruments to measure science literacy, civic engagement, and science citizenship. Data was collected from a proportionate stratified random sample of Pennsylvania agricultural education programs for a total of (n = 197) students. The multiple linear regression model was found to be a significant predictor of students' science citizenship and explained 57.8% of the variance. Civic skills efficacy, civic participation, value of science, science skills, and civic duty were significant predictors of students' science citizenship. Recommendations from results include incorporating civic education that builds students civic skills into agricultural education curriculum, educating pre-service agriculture teachers how to incorporate civic engagement into their programs, and further research to determine the extent to which agriculture teachers currently support students' civic engagement in their programs.

Keywords: science citizenship; science literacy; civic engagement

Introduction

The agriculture industry has changed drastically over the past 100 years, creating a disconnect between agriculture and consumers (Eyck, 2000). Since the majority of consumers are not directly linked to production agriculture, people are often uninformed and misinformed about the agriculture industry (Thomson & Kelvin, 1996). Many agricultural practices and technologies have thus become extremely controversial in society as a result of this misinformation. According to the Center for Food Integrity (2018), only 25% of consumer participants strongly agree with the statement "I trust today's food system", and only 30% strongly agree that "US farmers take good care of the environment" (Center for Food Integrity, 2018). When consumers do not trust the food system, they do not trust new technologies or practices that could make the industry more efficient or have less environmental impact. Considering that consumers influence how food is produced, rebuilding the trust between producers and consumers is important for continued advancements in the agriculture industry in order to feed a growing population.

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Climate change is a global challenge facing governments and industries alike. According to the Intergovernmental Panel on Climate Change, "warming of the climate system is unequivocal" and "human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history" (Pachauri et al., 2014, p. 40). Ninety-seven percent of climate scientists concur that global warming trends are likely due to human activities (Cook et al., 2016). However, according to a Gallup poll, while 66% of Americans believe climate change is caused by human activities, only 44% worry a great deal about global warming (Saad, 2019). This disconnect is especially present among agriculturalists in the United States. The National Climate Assessment (Hatfield et al., 2014) shows the agricultural industry is already being negatively affected by climate change. Changes in temperature, precipitation, water availability, and CO_2 levels negatively affect crop yields, quality, and prices (Hatfield et al., 2014). Despite these challenges, studies show that American farmers are less likely to believe in anthropogenic climate change than the American public (Mase et al., 2017). A survey of 5,000 Midwestern farmers revealed that while 66% believe climate change is occurring, only 8% believe it is anthropogenic (Arbuckle et al., 2013). Considering that farmers who believe the scientific consensus that climate change is occurring and caused by mostly human activities were significantly more likely to support mitigative action (Arbuckle et al., 2013), science literacy can be critical for combating climate change. Therefore, both an agricultural workforce and general population that is scientifically literate and civically engaged is imperative in order to effectively mitigate and adapt to climate change. In this study we operationally define *science literacy* as the science knowledge, attitudes, skills, and behaviors necessary to make informed decisions and participate in society regarding science issues, while *science citizenship* is any civic behavior or action regarding a science related problem or issue. In short, science literacy is "do you have the capacity to act", whereas science citizenship is "are you going to do anything about it?"

Having a civically engaged population is essential for solving issues at local, national, and global scales alike. While being knowledgeable about an issue is important for having an educated perspective, knowledge by itself does not result in positive change. Instead, civic action is what helps drive change and resolution of issues in society. For example, climate change mitigation occurs when people reduce their personal carbon footprint, vote for leaders who will enact policy changes, or join a local climate change organization. Thus, it is important to gain a better understanding of how and why people become civically engaged in order to develop future generations of engaged citizens.

Broadly, civic engagement is using civic knowledge, skills, and attitudes to participate in a wide variety of ways in order to address issues and make a positive difference in society. There are many components of civic engagement and ways in which one can be civically engaged, therefore there is not a comprehensive definition. People can be civically engaged through both political processes, such as voting, as well as non-political processes like organizing a fundraiser (Ehrlich, 2000). Civic engagement is not only beneficial for the individuals involved, but it also supports healthy communities and society (Pancer, 2015). Policy changes to solve or mitigate scientific issues do not automatically come to fruition; instead, steps must be taken by groups and individuals to research the issues, educate others, and advocate for policies through various forms of civic engagement. Voting, protesting, organizing a town hall meeting, and communicating with government representatives are all examples of ways people can push for change through civic engagement. Whether it is through the actions of one person or the actions of thousands, citizens have a voice that is essential for solving science-related issues.

Efforts have been made to increase science citizenship in broad education contexts, including interventions with roleplaying games (Gaydos & Squire, 2012), career related instructions (Salonen et al., 2018), and community participation (Roth & Lee, 2004). Harnessing the power of the internet and digital communication, citizen science projects, wherein large swaths of data are collected by everyday people, have become very popular. The argument can be made, that citizen science projects do more than just rally large groups of data collectors, but work to "democratize" science, and engage communities in civic ways (Kullenberg & Kasperowski, 2016).

A potential way to develop citizens who are both scientifically literate and civically engaged is through School-based Agricultural Education (SBAE). Agriculture is an applied science that uses scientific knowledge to address real-world problems, and thus plays a major role in solving challenges such as food security and climate change. There is enormous potential to develop science literacy and civic engagement in students through all three components of the three-circle model. For example, classroom/laboratory instruction can include curriculum that integrates and connects science and civic education. Through Supervised Agricultural Experiences (SAE), students can work with their teacher to develop and engage in service-learning projects. FFA can also provide students with opportunities to develop leadership skills and work to make their community a better place through civic participation. Due to its interconnectedness, the delivery of SBAE through the three-circle model may prove to be ideal for developing students' science citizenship, or civic engagement concerning science-related issues.

Aspects of civic engagement have been studied in the profession of Agricultural Education (Roberts & Edwards, 2018; Roberts & Edwards, 2015; Hoover et al., 2007; Bird et al., 2019), however, there is a dearth of literature concerning students' civic engagement and how agricultural education contributes to its development. Roberts and Edwards (2015) acknowledge that service-learning is still evolving in SBAE, and their historical study described the philosophical roots of service-learning as a method of instruction and how service-learning has been used in agricultural education. The study shows service-learning aligns with SBAE's three circle model, however, more research is needed to determine how service-learning in agricultural education impacts student learning (Roberts & Edwards, 2015) and civic engagement.

In another study, Bird, Bowling, and Ball (2019) determined the influence of reflection after taking part in FFA civic engagement activities on students' (n = 138) perceived civic responsibility. Results showed that students who participated in reflection after civic engagement activities gained higher levels of self-perceived civic responsibility compared to students who just participated in the civic engagement activity (Bird et al., 2019). A review of the Journal of Agricultural Education in the present study revealed that the Bird et al., (2019) investigation is the only published work in the journal with the term "civic engagement". While this research is important and demonstrates the importance of reflection in relation to civic engagement, there is a large gap in the literature concerning civic engagement in Agricultural Education.

Other scholars have researched aspects of science literacy (Baker et al., 2015; Shoulders & Myers, 2013; Thompson & Warnick, 2007; Thompson & Balschweid, 1999) in SBAE, although there is limited literature in this area as well. Thompson and Balschweid (1999) conducted a study to determine perceptions of integrating science into agriculture programs. They found that teachers have a positive perception of science integration and feel confident in teaching science (Thompson & Balschweid, 1999). Another study showed how students' science content knowledge increased after participating in a six-week socioscientific issues-based instruction (Shoulders & Myers, 2013). Perceptions and content knowledge provide valuable information to the profession, but more research is needed to describe a more holistic view of science literacy in agricultural education.

In order to solve global, scientific challenges such as climate change and food insecurity, citizens must be scientifically literate and civically engaged. While there is a dearth of literature regarding science citizenship in SBAE, there is great potential to further develop science literacy and civic engagement with this audience. The present study seeks to contribute to the literature regarding science literacy, civic engagement, and therefore science citizenship, in secondary agricultural education students.

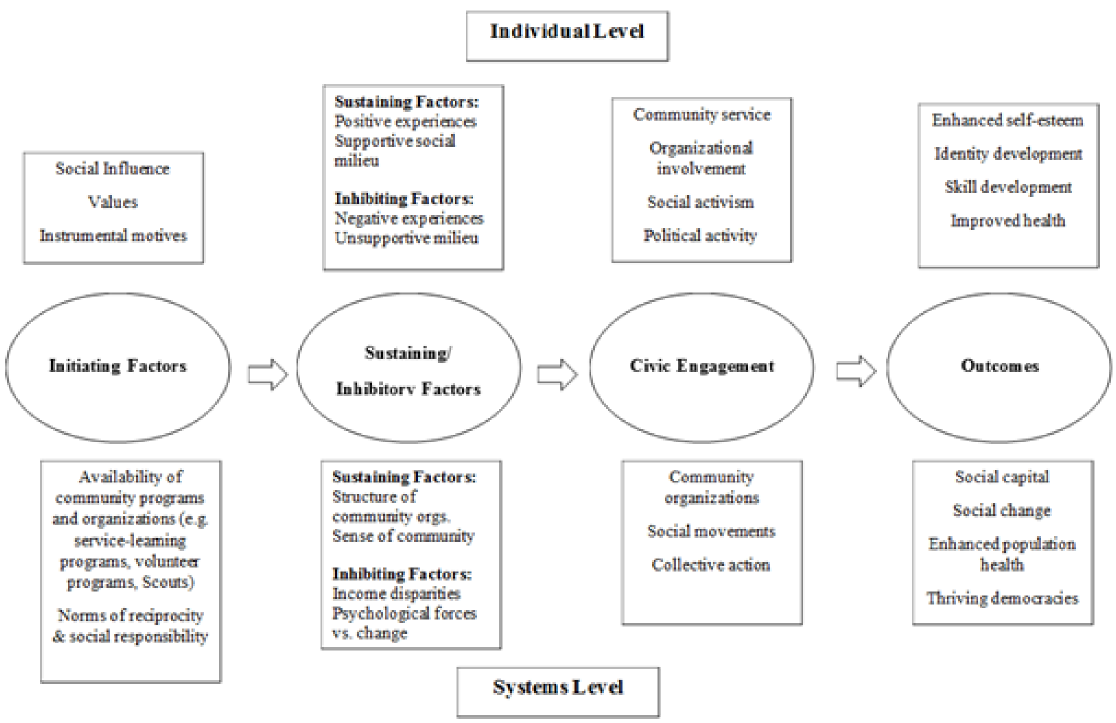
Literature Review

Theoretical Framework

Pancer's (2015) Integrative Theory of Civic Engagement serves as the theoretical framework of this study (See Figure 1). Pancer (2015) developed this theory of civic engagement in an attempt to address many of the various ways in which one can be civically engaged. The theory proposes that civic engagement occurs on two levels: the individual level and the systems level (Pancer, 2015). On the individual level, people become civically engaged due to initiating factors such as values and social influence (Pancer, 2015; Bobek et al., 2009). However, civic engagement will only continue if various sustaining factors are present and they outweigh inhibitory factors that may also be present (Pancer, 2015). Examples of sustaining factors include positive experiences, such as feeling like they "made a difference", as well as a supportive social milieu (Pancer, 2015; Pancer & Pratt, 1999). Inhibiting factors including lack of time and negative experiences may prevent individuals from continued involvement (Pancer, 2015). For example, a youth who has to watch their siblings after school while their parents are working probably will not have extra time to be involved in civic organizations. When an individual participates in sustained civic engagement, positive outcomes such as enhanced self-esteem and skill development are often the result (Pancer, 2015).

Figure 1

An Integrative Theory of Civic Engagement



Note: From Pancer, S. M. (2015). *The Psychology of Citizenship and Civic Engagement.* New York: Oxford University Press.

Research shows that social systems are important for initiating and sustaining civic engagement (Pancer, 2015). Factors that initiate civic engagement at the systems level include the presence of accessible organizations that encourage civic engagement as well as service-learning programs in schools (Pancer, 2015; Watts & Flanagan, 2007). Engagement at the systems level can be sustained if there is a sense of community and organizations have the structures to support civic engagement (Pancer, 2015). However, factors such as income inequality (Wilkinson & Pickett, 2009) and lack of trust between community members can inhibit civic engagement (Pancer, 2015). Civic engagement at the systems level is beneficial for society, resulting in positive outcomes such as lower crime rates, increased social capital, better educational achievement, and thriving democracies (Pancer, 2015; Putnam, 2000).

Both civic engagement and science literacy can be viewed as potential initiating factors for science citizenship. A person becomes an engaged citizen when they have the efficacy and ability to be involved, supportive social networks, the desire to make positive contributions, and they participate through various ways in their school/community. Considering science citizenship is a civic behavior regarding science issues such as climate change, for example, the components of civic engagement are influential for science citizenship. If someone does not believe they have the skills to be civically engaged, they probably are not going to become involved, whether the issue is connected to science or not. Components of science literacy are also included because people who have science citizenship should also be scientifically literate. People need a general knowledge of science, positive attitudes towards science, and science skills to be able to use science in their personal lives.

Science Literacy

The term science literacy was coined in the 1950s, during a time of rapid scientific advancements and national security concerns brought about by the Cold War. Hurd (1958) and McCurdy (1958) both called for science education to become a major part of the K-12 curriculum for all students in a way that focused on how science applies everyday life. In its broadest definition, science literacy is a general understanding of science and the ability to participate in society as an informed citizen with regard to science-related issues (DeBoer, 2000). An early definition of science literacy described someone with an understanding of (1) the interrelationships of science and society; (2) ethics that control the scientist in his work; (3) the nature of science; (4) differences between science and technology; (5) basic concepts in science; and (6) interrelationships of science and the humanities (Pella et al., 1966). Another influential definition by Shen (1975) suggested there are three types of scientific literacy: practical, civic, and cultural. Civic science literacy is the notion that citizens should have a basic understanding of science so they can participate in democratic processes regarding science-related issues such as health and the environment (Shen, 1975). Shen (1975) argued that civic science literacy was necessary for our increasingly technological society. Ultimately, there is not one universally accepted definition of science literacy; rather, there are many definitions that include various components or characteristics of scientific literacy such as science knowledge, attitudes towards science, and science-related skills and behaviors (DeBoer, 2000; Laugksch, 2000).

According to the National Academies of Science, Engineering, and Medicine (2016), there are four rationales for scientific literacy: the economic, personal, democratic, and cultural rationale. The economic rationale is a practical, logical argument for science literacy, which argues our economy increasingly requires a scientifically literate population to fill jobs and increase economic growth (NASEM, 2016). The personal rationale states that when people are scientifically literate, they are better able to lead healthier and more sustainable lives (NASEM, 2016). Similarly, the democratic rationale reasons a democratic society functions better when its citizens are scientifically informed (NASEM, 2016). On the other hand, the cultural rational is unique in that it simply states the sciences are important to the United States and Western culture because of the large influence they have had in our understanding of the world (NASEM, 2016). Hurd (1958) argued, "if education is regarded as a sharing of the experiences of the culture, then science must have a place in the modern curriculum" (p. 13).

There are multiple measures of science literacy that exist (Laugksch & Spargo, 1996; Bybee, 2008; OECD, 2007; Wenning, 2007; Gormally et al., 2012). However, the majority of measures focus on field specific content knowledge, and/or they only focus on one aspect of science literacy (Fives et al., 2014). For example, the measure developed by Wenning (2007) focused primarily on physics scientific content knowledge, and the measure developed by Gormally et al (2012) focused specifically on scientific skills. To address these limitations, Fives et al (2014) developed the Scientific Literacy Assessment in order to measure the scientific literacy of middle school students. Their framework for conceptualizing science literacy includes the following six components: (1) role of science, (2) scientific thinking and doing, (3) science and society, (4) science media literacy, (5) mathematics in science, and (6) science motivation and beliefs (Fives et al., 2014). Their framework guided the development of the instrument, which includes a measure on demonstrated science literacy (multiple choice questions that assess general science knowledge) as well as a measure on science motivations and beliefs (Fives et al., 2014).

Civic Engagement

Civic engagement is a broad term without a universal definition. Ehrlich (2000) defines civic engagement as:

> Working to make a difference in the life of one's community and developing the combination of knowledge, skills, values, and motivation to make that difference. It means promoting the quality of life in a community, through both political and non-political processes. (p. vi)

It is important to note that youth civic engagement refers to the active participation of youth regarding issues they identify are important, not what an adult identifies as important (Checkoway, 2011). While voting is a conventional form of civic engagement (Syvertsen et al., 2011) there are many ways in which youth can be civically engaged. Among voting-age youth populations, voting turnout has declined, however, civic engagement in the form of community service has increased (Syvertsen et al., 2011). Other forms of engagement include grassroots organizing, intergroup dialogue, and sociopolitical development (Checkoway & Aldana, 2013).

Youth engagement in civic activities is beneficial for both the individual and their communities (Bobek et al., 2009; Pancer, 2015). Research shows that youth civic engagement not only keeps youth from engaging in negative behaviors, it also has a multitude of positive impacts on their development (Pancer, 2015). Youth who are engaged have higher self-esteem (Pancer & Pratt, 1999), higher self-confidence (Pancer & Pratt, 1999), better relationships (Rose-Krasnor et al., 2006), and are more satisfied with their lives (Jimenez et al., 2009). Engagement helps youth develop practical competencies in adult life such as communication skills and leadership skills (Astin & Sax, 1998). Engaged youth also have more positive attitudes towards school and have greater academic success (Astin & Sax, 1998; Eccles et al., 2003). In addition, youth who are civically engaged have a stronger connection to their communities (Henderson et al., 2014) and are much more likely to be civically engaged as adults (Youniss et al., 1997; Astin & Sax, 1998).

In the words of Levine and Youniss (2006), "Citizens are made, not born; it takes deliberate efforts to prepare young people to participate effectively and wisely in public life" (p. 3). As such, there are many factors that influence and initiate civic engagement including social influence, values, and availability of civic organizations (Pancer, 2015). Similarly, Bobek et al. (2009) suggest four interrelated factors that are necessary for a person to be civically engaged: (1) social connections, (2) civic skills, (3) civic duty, and (4) civic action. Research shows that civic self-efficacy is another important factor that leads to civic engagement (Littenberg-Tobias & Cohen, 2016; Gastil & Xenos, 2010; Levinson, 2007). For example, a study by Manganelli, Lucidi, and Alivernini (2014) found that efficacy beliefs, rather than other factors such as civic knowledge, predicted civic engagement.

There are, however, barriers that prevent youth from experiencing civic engagement and its benefits. Negative experiences, income inequality, lack of time, and lack of civic opportunities are all examples of barriers to civic engagement (Pancer, 2015). In addition, a civic engagement gap exists in the United States between socioeconomic and racial groups (Levinson, 2007; Gaby, 2017) that is a barrier to civic engagement. Socioeconomic and racial inequalities exist in civic engagement due to systemic issues like racism, as well as barriers such as fewer opportunities for engagement (Flanagan & Levine, 2010; Levinson, 2007). For example, schools with more affluent student bodies provide more and better opportunities for civic engagement (Flanagan & Levine, 2010). In addition, comparisons of students in various academic tracks show that courses for college-bound students provide significantly more civic engagement activities than courses for students in lower academic tracks (Kahne & Middaugh, 2008).

Purpose

The purpose of this study was to describe the scientific literacy, civic engagement, and science citizenship of secondary agricultural education students in Pennsylvania. In addition, this study sought to identify the most important components of science literacy and civic engagement for building students' science citizenship. The descriptive correlational study followed a quantitative design (Field, 2013). This research aligns with Research Priority 7 of the AAAE National Research Agenda "Addressing Complex Problems" (Roberts et al., 2016). Within priority 7, this research aligns with Research Priority Question 2: How can teaching, research, and extension programs in agricultural leadership, education, and communication address complex interdisciplinary issues? (Roberts et al., 2016).

The following questions guided the study:

1. How scientifically literate are secondary agricultural education students?
2. To what extent are secondary agricultural education students civically engaged?
3. To what extent do secondary agricultural education students engage in science citizenship?
4. Which variables of science literacy and civic engagement best predict secondary agricultural education students' engagement in science citizenship in Pennsylvania?

Methods

Population and Sample

The target population of this study was secondary (9^{th} – 12^{th} grade) agricultural education students in the state of Pennsylvania. According to Krejicie and Morgan (1970), a sample size of (n = 374) was needed for generalization with a 95% confidence interval and 5% margin of error. To obtain a representative sample of the target population, proportionate stratified random sampling of agriculture programs by Pennsylvania regions was utilized. Stratified random sampling of programs instead of individual students allowed us to collect data from the recommended sample size of subjects in less time and fewer school visits, while still maintaining representation of the four regions. A total of 20 agriculture programs were selected, and we decided to try and collect data from 30 students per agriculture program in order to comfortably reach the sample size of *(n* = 374) needed for generalization to the population.

Data Collection

This study was approved by the Institutional Review Board of The Pennsylvania State University. An agriculture program that was not included in the main study was selected to participate in a pilot study (n = 29) students. The pilot helped select items to be included in the questionnaire and determine reliability. Cronbach's alphas for the pilot study were reported for each construct of the questionnaire: Value of Science (α = .94), Science Skills (α = .87), Science Beliefs (α = .71), Civic Duty (α = .89), Civic Skills Efficacy (α = .87), Neighborhood Social Connections (α = .82), Civic Participation (α = .76), Competence for Civic Action (α = .93), Political Voice (α = .87), and Critical Consumer of Political Information (α = .85). The coefficients indicated the questionnaire was reliable (Gliem & Gliem, 2003).

An initial email solicitation was sent out to each of the agriculture teachers of the 20 randomly selected programs. The email provided information about the study and a link to brief questionnaire where they could indicate whether or not they were willing to have their program participate in the study. After one week, a reminder email was sent to all teachers who had not responded. Another reminder email was sent out if needed, and we called teachers who did not respond to the second reminder email. When teachers declined participation, another school in the region was randomly selected and sent an initial solicitation email. When teachers elected to have their programs participate in the study, an email was sent that detailed the parental permission process and a mutually convenient date was scheduled for us to visit and administer the questionnaire. Due to some teachers declining to participate, a total of 39 programs were asked to participate in the study. However, data was only collected from 10 programs who agreed to participate for a total of (n = 197) students. Data was collected from each of the schools over the course of five weeks. We personally visited each program and administered the questionnaire. Prior to administering the questionnaire, we provided information about the study and collected parental permission slips. The questionnaire was administered online via Qualtrics.

Instrumentation

The questionnaire was adapted from three separate instruments to collect quantitative data regarding science literacy, general civic engagement, and science citizenship. The first section of the questionnaire was adapted from Fives et al. (2014), and measured students' science literacy through four constructs. The first science literacy construct consisted of 19 multiple choice questions that tested students' understanding of the following components of science literacy: the *role of science*, *scientific thinking and doing*, *science and society*, *science media literacy*, and *mathematics in science* (Fives et al., 2014). The second construct measured the *value of science* through 6 Likert-type items. An example of items included, "Compared to most of your other activities, how useful is what you learn in science? (1 = Not useful at all, 5 = Extremely useful)." The construct *science skills* was measured through 8 Likert-type items including, "I know how to use the scientific method to solve problems (1 = Strongly disagree, 5 = Strongly agree)." The fourth construct measured *science beliefs*, which included Likert-type items such as "The most important part of doing science is coming up with the right answer (1 = Strongly disagree, 5 = Strongly agree)."

The second section of the questionnaire was adapted from Bobek et al. (2009), and measured students' general civic engagement through four constructs consisting of Likert-type questions. *Civic duty* was measured with 12 items such as "It is important to me to contribute to my community and society (1 = Strongly disagree, 5 = Strongly agree)." The *civic skill efficacy* construct consisted of 6 items including, "How well do you think you would be able to contact an elected official about the problem (1 = I definitely can't, 5 = I definitely can)." There were 6 items that measured *neighborhood social connections*. An example item included "Adults in my town listen to what I have to say (1 = Strongly disagree, 5 = Strongly agree)." The fourth construct was *civic participation* and was measured through 8 items such as "How often do you help make your town a better place for people to live? (1 = Never, 5 = Very often)."

The third section of the questionnaire was adapted from Flanagan et al. (2007), and measured students' science citizenship through three constructs: *competence for civic action, political voice*, and *critical consumer of political information*. These constructs were adapted to focus on civic behaviors related to science issues. The first construct measured *competence for civic action* through 9 Likert-type items centered around the following prompt: "If you found out about a problem in your community that science might be able to address/solve (for example the local stream was being polluted, or an invasive species was affecting the community's agriculture industry) and you wanted to do something about it, how well do you think you would be able to do each of the following?" Examples of the items included "Create a plan to address the problem (1 = I definitely can't, 5 = I definitely can)" and "Call someone on the phone that you had never met before to get their help with the problem (1 = I definitely can't, 5 = I definitely can)." The second construct measured *political voice* through 3 items such as "When you think about your life after high school, how likely is it that you would do each of the following? 'Contact or visit someone in government who represents your community regarding a science related issue' (1 = Extremely unlikely, 5 = Extremely likely)." The construct *critical consumer of political information* was also measured through 3 items including "I listen to people talk about scientific issues even when I know that I already disagree with them (1 = Does not describe me, 5 = Describes me extremely well)." Thresholds used to interpret what the data means for each construct are detailed in Table 1.

The demographics section contained 9 items: gender, race/ethnicity, grade, number of agriculture classes taken, final grade in science class, school, region, participation in FFA and SAE, and importance of FFA and SAE.

Table 1

Construct Thresholds

Construct	Thresholds for Data Interpretation
Value of Science	1 – 2.4 = Low Value; 2.5 – 3.5 = Moderate Value; 3.6 – 5 = High Value
Science Skills	< 3 = Low Skills; > 3 = High Skills
Science Beliefs	< 3 = Weak Beliefs; > 3 = Strong Beliefs
Civic Duty	1 – 2.4 = Low Civic Duty; 2.5 – 3.5 = Moderate Civic Duty; 3.6 – 5 = High Civic Duty
Civic Skills Efficacy	1 – 2.4 = Low Efficacy; 2.5 – 3.5 = Moderate Efficacy; 3.6 – 5 = High Efficacy
Neighborhood Social Connections	< 3 = Low Connections; > 3 = High Connections
Civic Participation	1 – 2.4 = Low Participation; 2.5 – 3.5 = Moderate Participation; 3.6 – 5 = High Participation
Competence for Civic Action	1 – 2.4 = Low Competence; 2.5 – 3.5 = Moderate Competence; 3.6 – 5 = High Competence
Political Action	1 – 2.4 = Low Political Action; 2.5 – 3.5 = Moderate Political Action; 3.6 – 5 = High Political Action
Critical Consumer of Political Information	1 – 2.4 = Low Critical Consumer; 2.5 – 3.5 = Moderate Critical Consumer; 3.6 – 5 = High Critical Consumer

Validity and Reliability

A pilot test of the questionnaire was conducted to help select items to be included in the questionnaire and determine reliability. Cronbach's alphas for the present study were reported for each construct of the questionnaire: Value of Science (α = .86), Science Skills (α = .83), Science Beliefs (α = .90), Civic Duty (α = .87), Civic Skills Efficacy (α = .86), Neighborhood Social Connections (α = .82), Civic Participation (α = .78), Competence for Civic Action (α = .92), Political Voice (α = .86), and Critical Consumer of Political Information (α = .86). The coefficients indicated the questionnaire was reliable (Gliem & Gliem, 2003). Face and content validity were established using a panel of experts in science literacy and civic engagement.

Data Analysis

The quantitative data collected from the questionnaire was analyzed based on the research questions using the Statistical Package for the Social Sciences (SPSS 26) software. The alpha level was set at .05 for all significance tests. After cleaning the data, the final sample for analysis was (n = 197). Since the sample size did not meet the threshold for generalization (n = 374) according to Krejcie and Morgan (1970), early and late respondents were compared on science knowledge and each of the 10 constructs. Independent samples t-tests showed there were no significant differences, except for science knowledge (p = .04), between early and late respondents. According to Radhakrishna and Doamekpor (2008), non-respondents are similar to late respondents in their survey response. Based on this analysis, it is concluded that responses of the 197 participants may be generalizable to the population.

Descriptive statistics, including means and standard deviations, were used to analyze science knowledge and each of the 10 constructs. An overall mean for Total Science Citizenship (includes all three science citizenship constructs) was also calculated. Frequencies and percentages were used to analyze the following demographic items: gender, race/ethnicity, grade, number of agriculture classes taken, and final grade in science class.

To determine which variables of science literacy and civic engagement are most important for building students' science citizenship, a multiple linear regression was utilized. Prior to analysis, the assumptions of multiple linear regression were checked and no violations were found (Field, 2013). All components from the science literacy and civic engagement sections (science knowledge and 7 constructs) were loaded into the regression as independent variables. The three Science Citizenship constructs were not loaded into the regression because they were components of the dependent variable, Total Science Citizenship.

Results

Research Question 1: *Describe SBAE students' science literacy*

Of the students who participated in the study (n = 197), 52% of students were female (Male = 47%, Other = 1%). The students were predominately white (92%), and a majority were upperclassman (Grade 9 = 11%, Grade 10 = 21%, Grade 11 = 33%, Grade 12 = 35%). The first research question was to describe the landscape regarding science literacy in secondary agricultural education. Students scored an average of 10.88 (SD = 4.20) out of 19 possible points (57.3%) on the science knowledge portion of the questionnaire, while self-reporting levels of beliefs towards science, their science skills, and their value of science (See Table 2).

Table 2

Descriptive Analysis of Science Literacy

Measure	*M*	*SD*
Science Knowledge	10.88	4.20
Value of Science[a]	3.44	.79
Science Skills[b]	3.79	.66
Science Beliefs[b]	4.07	.68

Note: Science Knowledge is scored out of 19 possible points. The three constructs are on a 5-point Likert scale.
a. 1 = Not at all interesting/useful/important, and 5 = Extremely interesting/useful/important.
b. 1 = Strongly disagree, and 5 = Strongly agree

Research Question 2: ***Describe SBAE students' civic engagement***

The second research question was to describe the civic engagement of secondary agricultural education students. Participants' highest component of civic engagement was their civic duty (*M* = 3.98, *SD* = .60), and their lowest component was civic participation (*M* = 2.77, *SD* = .80). (See Table 3)

Table 3

Descriptive Analysis of Civic Engagement

Measure	*M*	*SD*
Civic Duty[a]	3.98	.60
Civic Skills Efficacy[b]	3.24	.90
Neighborhood Social Connections[c]	3.35	.77
Civic Participation[d]	2.77	.80

a. 1 = Not at all important/Strongly disagree/Not well at all, and 5 = Extremely important/Strongly agree/Extremely well
b. 1 = I definitely can't, and 5 = I definitely can
c. 1 = Strongly disagree, and 5 = Strongly agree
d. 1 = Never, and 5 = Very often/Every day/5 times or more

Research Question 3: ***Describe SBAE students' science citizenship***

Describing secondary agricultural education students' science citizenship was the purpose of research question 3. Students' total Science Citizenship (comprised of *Competence for Civic Action*, *Political Voice*, and *Critical Consumer of Political Information* constructs) had a mean of 2.97 (*SD* = .87). (See Table 4)

Table 4

Descriptive Analysis of Science Citizenship

Measure	*M*	*SD*
Competence for Civic Action[a]	3.32	.90
Political Voice[b]	2.67	1.05
Critical Consumer of Political Information[c]	2.91	1.15
Total Science Citizenship	2.97	.82

a. 1 = I definitely can't, and 5 = I definitely can
b. 1 = Extremely unlikely, and 5 = Extremely likely
c. 1 = Does not describe me, and 5 = Describes me extremely well

Research Question 4: *Predicting SBAE students' science citizenship*

The fourth research question was to determine which constructs of science literacy and civic engagement are most important for building agricultural education students' science citizenship. The model was found to be a significant predictor of students' science citizenship, F (8,178) = 30.53, $p < .001$. The science literacy and civic engagement constructs were found to explain 57.8% ($R^2 = .578$) of the variance in students' science citizenship. Five of the nine variables were statistically significant predictors of students' science citizenship: Value of Science ($\beta = .21, p < .001$), Science Skills ($\beta = .16, p = .03$), Civic Duty ($\beta = .13, p = .03$), Civic Skills Efficacy ($\beta = .37, p < .001$), and Civic Participation ($\beta = .25, p < .001$). The standardized coefficients (β) show that Civic Skills Efficacy and Civic Participation are the strongest predictors of students' science citizenship (See Table 5). For example, when all other variables are held constant, a one standard deviation increase in civic skills efficacy results in a .37 standard deviation increase in science citizenship.

Table 5

Multiple Linear Regression Analysis for Science Citizenship

Predictors	*B*	SE	*β*	*t*	*p*-value
Science Literacy					
Science Knowledge	-.004	.01	-.02	-.38	.706
Value of Science	.21	.07	.21	3.24	.001*
Science Skills	.20	.09	.16	2.21	.028*
Science Beliefs	-.03	.06	-.03	-.49	.624
Civic Engagement					
Civic Duty	.18	.08	.13	2.27	.025*
Civic Skills Efficacy	.34	.05	.37	6.25	.000*
Neighborhood Social Connections	-.02	.06	-.02	-.36	.720
Civic Participation	.26	.06	.25	4.16	.000*

Note: $R = .761$, $R^2 = .578$, $F = 30.53$, $p < .001$.

Conclusions

Limitations

Generalizing the results of this study to the population of secondary agricultural education students in Pennsylvania should be done with caution. The sample size used for analysis ($n = 197$) does not meet the sample size set by Krejicie and Morgan (1970) for a 95% confidence interval and 5% margin of error.

While comparison of early and late respondents indicated the study to be generalizable to the population (Radhakrishna and Doamekpor, 2008), the results should be interpreted carefully.

There are a few ways in which the study could be improved. First, instead of taking a stratified random sample of agriculture programs in Pennsylvania, taking a stratified random sample of agricultural education students in Pennsylvania would have been better. Given the difficulty to acquire a roster of every agricultural education student in Pennsylvania, this approach was deemed impractical. In addition, having more participants would increase the study's statistical power and generalizability. While most students completed the questionnaire in approximately 20 minutes, there were some students who took longer to finish, so finding some way to shorten the instrument may prove to be beneficial in reducing survey fatigue.

Research Question 1: ***Describe SBAE students' science literacy***

The aim of the first research question was to describe secondary agricultural education students' science literacy. Broadly, science literacy is having the science knowledge, skills, and attitudes necessary to engage in society as an informed citizen (DeBoer, 2000; Fives et al., 2014). The results indicate that while students have somewhat strong beliefs in the nature of science ($M = 4.07$), find science to be moderately useful ($M = 3.44$), and possess a moderately high amount of science skills ($M = 3.79$), their science knowledge score was low ($M = 10.88$, 57.3%). In the development of the original measure, middle school students displayed similar marks on the science knowledge portion with a mean of 15 correct out of 26 (58%) (Fives et al., 2014). This is troubling considering the participants in this study were in 9th – 12th grade, with over 60% of participants in 11th and 12th grade.

It is important to keep in mind that the science knowledge portion of the questionnaire did not focus on specific science content knowledge that one would find on a chemistry or biology exam. Instead, the multiple-choice questions focused on measuring students' understanding of the role of science and reasoning/critical thinking skills, for example. Participants scored low on the science knowledge component of the questionnaire because they lacked the critical thinking and reasoning skills to answer the problems, not because they are lacking science content knowledge. Ideally, agricultural education courses provide a great opportunity for students to develop critical thinking skills considering students learn about science topics in real-world contexts. It is imperative agricultural education purposefully works to develop students' critical thinking skills so they can make informed science-related decisions in their lives.

The science literacy section of the questionnaire was not adapted to be agriculture specific in order to encompass a broad definition of science literacy. One of the questions in the *value of science* construct asked, "Compared to most of your other activities, how useful is what you learn in science?" When administering the questionnaire, there were a couple of students who asked if that question was referring to their science classes or agriculture classes. Considering that agricultural education gives students the opportunity to apply science content knowledge and skills in real agricultural contexts (NAAE, n.d.), agricultural education students should understand the important role science plays in the agriculture industry and thus value science. However, students reported they viewed science only moderately useful and important ($M = 3.44$). Perhaps students were thinking about the value of science on a more personal level instead of in a broader, societal context. Nevertheless, it is important to help nurture students' value of science through agricultural education because students engage in topics they deem as important and valuable.

Research Question 2: ***Describe SBAE students' civic engagement***

The second research question focused on describing agricultural education students' civic engagement. The civic engagement portion of the questionnaire measured students' civic engagement broadly. Results indicated students have moderately high levels of civic duty ($M = 3.98$), which refers to the desire to make a difference in their communities. They also have moderate levels of efficacy regarding civic skills (*M* = 3.24), and perceive moderate levels of neighborhood social connections in their community (*M* = 3.35). However, those perceptions do not seem to be reflected in their civic participation (*M* = 2.77). Just as there are many factors that initiate and sustain civic engagement, according to Pancer's (2015) Integrative Theory of Civic Engagement, there are also a variety of reasons why students do not participate. Lack of time to engage, past negative experiences, and low self-efficacy are all factors that can inhibit civic engagement (Pancer, 2015). Lack of access to civic engagement opportunities could be another reason why students did not report higher levels of civic participation. Research shows that college-bound students are offered more opportunities for civic engagement in school than other students (Kahne & Middaugh, 2008). So, for many students in agricultural education who are not going to college, their only opportunities for civic engagement may be through their agricultural education program. Agricultural education can be an excellent place for students to become civically engaged about issues they identify as important in their communities. For example, students could engage in service-learning in their Environmental Science course, develop a Service-Learning SAE project, or work with their fellow FFA members to identify and address a need in their community.

Research Question 3: ***Describe SBAE students' science citizenship***

The goal of the third research question was to describe students' science citizenship, which is science focused civic engagement. Students believed they could "maybe" complete a variety of actions in response to a science-related issue (*M* = 3.32), which was very similar to the results from the civic skills efficacy construct that focused on general civic engagement skills (*M* = 3.24). The similarity is expected because if a student does not know how to write a letter to a representative concerning poverty, they also will likely not know how to write a letter to a representative concerning climate change.

Another construct regarding science citizenship, political voice, focused on the likelihood of students engaging in various ways after high school regarding science-related problems. Students reported they would "maybe" do things like contact someone in government regarding a science-related issue (*M* = 2.67). Since the students believe science is only moderately important, it makes sense that they do not have a strong desire to become involved in science related issues later in life.

Results indicated that students believe the construct *critical consumer of political information* describes them "moderately well" (*M* = 2.91). This construct includes being able to listen to what others have to say as well as trying to determine if news articles are biased concerning scientific issues. As discussed previously, having critical thinking skills is important for being able to make informed decisions.

Research Question 4: ***Predicting SBAE students' science citizenship***

The fourth research question was to determine which variables of science literacy and civic engagement were most important when developing students' science citizenship. MLR revealed that civic skills efficacy, civic participation, value of science, science skills, and civic duty were all significant predictors of science citizenship. These results are supported by Pancer's (2015) Integrative Theory of Civic Engagement, the theoretical framework for this study, which shows there are many factors that initiate and sustain civic engagement, including your values, social influence, availability of organizations, and positive experiences participating. Civic skills efficacy and civic participation were the strongest predictors. These results are consistent with other studies that have also shown civic efficacy is a positive predictor of youth civic engagement (Manganelli et al., 2014). When students have experience being civically engaged, their self-efficacy increases, thus making it more likely they will participate in other ways. Students' value of science was also a significant predictor of science citizenship. In the words of Checkoway (2011, p. 342), "When young people identify their own issues … it can awaken their spirit and move them into action." If someone does not believe science is useful, or views science related issues as unimportant, they are not going to invest time or effort into science citizenship.

The results showed that science knowledge, science beliefs, and neighborhood social connections were not significant predictors of science citizenship. It was expected that science knowledge probably would not predict science citizenship considering there are many contemporary examples of groups who are civically engaged in scientific issues that do not necessarily exhibit high scientific content knowledge regarding those issues (pro-GMO food labeling groups, anti-childhood vaccine groups, climate change deniers, etc.).

Recommendations

To help agriculture students develop into science citizens, agriculture teachers should incorporate civic education into SBAE. Considering that civic skills efficacy was the strongest predictor of science citizenship in the regression model, it would be wise for teachers to focus building students' civic skills and thus their confidence in those abilities. Examples of civic skills include writing a letter to a representative, organizing and running a meeting, calling experts regarding a problem, and advocating for something. By including more civic education into SBAE, we are giving students the tools they need to be effective science citizens.

Civic engagement will not occur or have impactful results if teachers do not know or feel confident incorporating civic education into their curriculum. Thus, including civic education and engagement opportunities into pre-service teacher programs is recommended. Pre-service teachers should learn what civic engagement is, the benefits of civic engagement, its barriers, and how to incorporate civic engagement into agriculture curriculum. This could be done through a course specifically focused on youth civic engagement, or in true "learning by doing" fashion, pre-service teachers could experience civic engagement themselves by taking part in a service-learning project, for example. Finally, studies should be conducted to compare the science literacy, civic engagement, and science citizenship between students who are in agricultural education and those who do not take agricultural education courses. Such studies would provide insight into whether agricultural education effects students' science citizenship, as well as areas where agricultural education can continue to improve.

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