

Impacts of Scientific Literacy on Rural Sustainability

Subject & Problem

This paper reports on conclusions drawn from qualitative interviews and quantitative surveys of over 50 agricultural professionals and agricultural instructors in regards to their opinions about rural sustainability and their perceptions of ecological, economic, and social risks to food production. A key objective of three-dimensional science learning is to prepare students to make scientifically-informed decisions as adult citizens (Rudolph and Horibe, 2016), but the manner in which NGSS addresses sustainability may not fully prepare students to use evidence to increase their adoption of sustainable knowledge and practice (Feinstein & Kirchgasler, 2015). This consideration is particularly relevant for science instruction in rural schools. Rural populations comprise less than 20% of the US population but inhabit over 97% of the country's land area (US Census Bureau, 2018). Land used for livestock, cropping, and private forests comprises 72% of the land area of the contiguous United States (Merrill & Leatherby, 2018). Given the decreasing land and resources available for agriculture, growing challenges due to human-caused ecological disturbances (particularly climate change, diminishing water resources, and loss of biodiversity), and rising demands for food from rising human populations, decisions in regards to agricultural production will have lasting and widespread ramifications.

This paper addresses questions of how varying levels of scientific literacy affect the ecological, social, and economic sustainability of American food production and consumption through the lens of motivation and situated learning theories. In this case, the term *motivation* is used to refer to the processes of initiating and sustaining particular behaviors (Schunk, Meece, and Pintrich, 2014). The values and identity that underlie motivation most strongly predict people's choices and decisions (Linnenbrink-Garcia, *et al.*, 2016), and motivation is a key determinant of cognitive engagement (Blumenfeld, Kempler, and Krajcik, 2006). A greater understanding of how values and identity affect adoption of sustainable knowledge and practice in agricultural communities could provide valuable insights for goals of creating more sustainable rural landscapes and communities. As such, this study sought to address two primary research questions:

- 1) What do rural agriculturalists perceive to be the key threats to ecological, social, and economic sustainability in rural landscapes and communities?
- 2) What do agriculturalists recognize as potential solutions to these threats?

Design & Procedure

Setting & Participants: between June of 2017 and August of 2018, I surveyed and interviewed 51 agricultural professionals from 14 states. All participants had direct personal and professional connections to the agriculture industry. While there was an even mix of political affiliations, most of the participants had a bachelor's degree or higher. Over half of the participants were Millennials, and almost a third were from Generation X. More than three fourths of the participants self-identified as living in a rural or semi-rural location.

Methods, Data, and Analysis: Participants were recruited using professional email list-serves and agricultural pages on social media. The semi-structured interviews were conducted by phone, by video conferencing, or in person (individually, in pairs, or in focus groups). Study participants were compensated for their time. All participants completed a survey prior to the interview providing demographic information as well as their opinions on climate change, GMOs, and organic agriculture. While the interview questions were prepared in advance, participants were given flexibility to deviate from the prepared questions and to bring up other relevant topics. Participants' responses were regularly paraphrased by the interviewer to check for accuracy of the interpretation of their statements.

Data collection occurred under two separate studies. The first pertained exclusively to agricultural educators, involving interviews of 16 participants during the summer and fall of 2017. Nine questions served as the basis for these interviews; four focused on agricultural sustainability while the remaining five centered on teaching practices and the use of situated learning. The 35 participants in

the second study included a range of agricultural professionals, including agricultural instructors as well as farmers, agricultural nutritionists, engineers, marketers, and others. Five questions served as the basis for this set of interviews. The first two questions pertained to how actions of individuals inside and outside of the agriculture industry might impair the work of future agriculturalists; the term “sustainability” was avoided due to its association among agriculturalists with particular production methods. The third and fourth questions focused on short-term and long-term solutions to these issues. The last question pertained to how to best prepare future agriculturalists to enact these changes through formal and/or informal education. The interviews were recorded. Transcripts of the audio recordings and verbatim field notes were transcribed for coding purposes. Coding was performed using computer-assisted strategies, and the conclusions were confirmed with some of the study participants for accuracy.

Findings

Perceived Risks to Sustainable Agriculture: the perception of the consumers’ limited scientific literacy was the most frequently-cited threat to sustainable agricultural production among those interviewed. “A lack of education is really driving their decisions instead of basing them on fact,” argued one participant. Almost all participants felt that consumers lacked the understanding necessary to make informed purchases, resulting in consumer trends that worked against the sustainability of food production. Participants felt that this inhibited their abilities to adopt technologies that could result in an increase in yields while minimizing negative ecological consequences. Said one participant, “They may have the best of intentions but they don’t understand that some GMOs and other technologies might have fewer environmental impacts.” Said another, “If the consumer wants a non-GMO label, that is what is going to be out there regardless of if that is the best product.”

Participants also frequently mentioned the passage of ineffective and overly-burdensome agricultural legislation developed by agriculturally-illiterate legislators. “People like that are making policies and laws and not taking into account the practical implications of the laws they make,” argued one participant. Most generally felt that some government regulation was necessary, but they also expressed concerns about the implementation of regulations that lacked a sufficient basis in evidence or that disproportionately harmed smaller farming operations. Said one farmer, “We may change our operations to meet the needs and values of modern consumers and by the time we change our operations they may end up changing their values again.” A common concern was that the cost of meeting government regulation was easier for large operations to afford due to their economies of scale. This in combination with pressure from financial institutions to add more revenue by expanding production (such as by unnecessarily adding more cattle, known as “banker’s cows”) pushed operations to become increasingly larger. This was seen as potentially reducing the ability of farmers to fully ensure animal welfare, adopt sustainable land use practices, and engage in their rural communities.

Decreasing commodity prices from coerced oversupply coupled with decreased international trade and increasing tariffs further reduced the ability of farmers to adopt sustainable practices. Farm income on average has fallen over 50% in the last five years, with another decrease of up to 7% expected in this year alone (Daniels, 2018). These trends have forced consolidation and other changes throughout the industry: “There are now only 2-3 companies to buy from instead of a dozen...we used to work together more, but now it’s more cutthroat.” Said another, “There has been a loss of that sense of community and now it is every man for himself.” Farmers often claimed that they had little bargaining power both in regards to the cost of their inputs as well as the price that they received for their products. This also led to an increase in farm foreclosures and the amount of undeveloped farmland that is being lost to urban sprawl, resulting in changes to the size, culture, and makeup of rural communities. The increased buying power of housing developers has also made it nearly impossible for new farmers to afford to start their own operations, often forcing them to seek employment on large farms instead.

Perceptions of Cultural Schisms: feelings of isolation and resentment were palpable throughout the interviews. Farmers and other agriculturalists clearly harbored strong emotions from having their practices judged by people that they felt were “disconnected” and “poorly informed” about production agriculture. One participant commented that she felt like she was branded as an “Evil Monsanto Enemy” because her family raised conventional crops such as corn and soybeans. Many felt belittled or demonized by animal rights activists for practices that they argued were necessary for the wellbeing of their animals. Economic consequences of animal activist legislation further compounded their frustration and economic hardships. “It’s just a shift but it costs a ton of money [when we] need to do upgrades of our facilities,” said one farmer, adding, “We don’t have the kind of money to make those kinds of changes. It is more of an image problem than a production problem.”

Many insinuated that the public perceived farmers to value profits more than the welfare of their animals or the care of their land. “We kind of expect the consumer to know that we don’t abuse our animals, that we feed our animals 2-3 times a day and treat them like children. ... The consumer doesn’t see that.” Said another, “On social media, [agriculturalists] are being attacked on there...and it is just not fair representation of what is actually going on.” When asked, multiple participants agreed that the sense of separation between rural and non-rural populations coupled with a perception of agricultural illiteracy among consumers increased the likelihood that agriculturalists might dismiss calls for more sustainable practices despite evidence to support their implementation, especially if they appeared to originate from outside of an agricultural community of practice. “There is always some pride growing up on a farm, and when you mess with that community, farmers get offended.”

Much of this resentment could potentially be the outcome of perceptions of unfairness by agriculturalists. For example, conventional agriculturalists (and some organic producers) perceived the organic label to be misleading, purporting to deliver a safer, more nutritious, and more sustainable product despite limited evidence for this (Magkos, Arvaniti, & Zampelas, 2006). However, none had concerns with the use of kosher labels, potentially due to the perception that the kosher label lacked an equivalent implication for non-kosher products. Similarly, livestock producers supported those who chose vegetarian or vegan diets out of legitimate health or religious reasons, but expressed bitterness at those who did so for reasons of animal welfare, feeling that it implied that they did not care for the wellbeing of their animals.

Perceived Risks from Within Agriculture: while the vast majority of the opinions of the interviewed participants generally aligned to the scientific consensus on issues such as climate change and GMOs, there were also numerous incidences that suggested that agricultural producers themselves also sometimes lacked the scientific literacy necessary to consistently make fully-informed decisions. One participant estimated that 40% of farming decisions were made because of the recommendations of agricultural salespersons. Multiple individuals also suggested that poorly-informed ‘single issue voting’ resulted in election of candidates who enacted immigration and trade policies that harmed the agriculture industry. Multiple participants also commented on the extensive amount of data now common to farming, and the inability of many agriculturalists to adequately utilize this data in their operations due to a lack of expertise and training.

Multiple participants remarked on the generation gaps that appeared to exist between younger and older agriculturalists. “The average age of our farmer is now about 50 years old. If you were to go up to them and carry on a conversation about climate change, which you can see is evident, they will tell you it is a bunch of baloney,” said one farmer in his early 20s. Other participants suggested that older farmers often lacked the motivation and/or the capabilities to adopt major changes at such a late stage in their careers. Another suggested that this increased the risk of burdensome legislation: “If we can’t accept that we need to make changes, then regulations will be put in place.” Some participants alluded to the idea that the hesitancy to adopt new practices threatened the work of future agriculturalists. Said one, “We have good farmers and we have some that are not as sustainable. Some are putting corn on hillsides, not using cover crops or contour strips or other conservation practices.

... If we don't take care of the land it won't be productive and we won't be able to feed a growing population."

Proposed Solutions: while a number of ideas were proposed as solutions for these problems, education was by far the most prominently mentioned option. Most of the participants felt that formal instruction was necessary at the high school level or earlier in order to prepare students to "talk about the role of agriculture in meeting the needs of a growing human population sustainably." Said one participant, "I find people to be lazy when it comes to checking out info. If it matches what they want to hear, they don't check it out. General agricultural education [is needed] for all students at school."

Many participants argued that science literacy and media literacy were critical to consumer and producer education. One asked, "How do we equip young people today with critical thinking skills to ask why, how does it happen, why does it make sense, and to justify that point of view based on fact?" Additionally, participants overwhelmingly felt that in order to be effective, instruction for agricultural literacy also needed to be "hands-on", by which they meant authentic, situated learning experiences. "Something we need to have is more hands-on training or opportunity for kids to get on farms. In an urban setting, this might be a community garden where they learn this is how stuff grows," suggested one participant. Said another, "Hands-on education is critically important. [In terms of] solving problems of globalization or population surplus or growth, I think really seeing and understanding a problem in the real world rather than theoretically is super important because it makes the need for solutions more relevant and imminent." One participant suggested that personal contact was critical for students to be willing to consider evidence that they otherwise might dismiss: "Consumers as a whole, there are so many people that are hard to convince. They have a hard time believing... they won't believe that message until they actually meet a producer." Many of their sentiments reflected the theories of Lave & Wenger (1991), suggesting that only through legitimate peripheral participation in an agricultural community of practice could a student fully comprehend the evidence and acquire the motivation to want to make informed choices about food production and consumption. Interestingly, a number of participants also argued that the reverse could also be true. When asked if students could potentially change the practices of farmers, one participant replied: "Oh definitely. It's not that older farmers don't care; ignorance is bliss. It's just that they don't know. Yeah, [this] would be a great way for getting multi-generational learning to happen."

Alternative Interpretations, Bias, Reliability, and Validity

While a personal background in agriculture provided me with a valuable perspective for this work, I also checked my own conclusions against other published work to minimize bias. While the background of the participants reflected a wide range of cultural and political viewpoints across a sizeable geographical area, it is entirely likely that these views are not fully representative of American agriculture as a whole. In this case, the average participant was certainly younger and more educated. To minimize selection bias, these interviews were primarily described as being about the future of the agriculture industry instead of sustainability. Despite effort to remain as neutral as possible on these topics, it is undeniable that my own background and viewpoints may have influenced some of the answers from the participants. When responses were specifically influenced by previous experience with me, these incidences were specifically noted in the interview and/or by the participant.

Contributions and General Interest

This work could have important implications for both rural and non-rural education. Rural areas produce almost all of the nation's food and fiber, with fewer than 2% of the population making management decisions for the majority of the nation's land (Merrill, & Leatherby, 2018). Rural agriculturalists must make difficult decisions that balance economic, ecological, and social considerations at the local level while addressing national and global considerations, including issues like climate change that are directly addressed by NGSS. Choices made by consumers in non-rural areas can either hinder or enhance the likelihood that agriculturalists will be willing and able to adopt

more sustainable knowledge and practice, particularly given that the practices of farmers are increasingly subject to the demands of consumers. The extent to which both rural and non-rural students are prepared, capable, and motivated to use evidence to make informed decisions about food production and consumption could have lasting implications for the overall sustainability of the nation.

Agricultural sustainability is what is known as a “wicked problem”, or a consideration in which the definition of the problem and the solution to that problem are both controversial and unclear. The limited adoption of sustainable knowledge and practice is often seen as an outcome of limited science literacy and comprehension. However, the results of these interviews suggest that this problem is much more nuanced and complex than that, entailing issues of values, identity, respect, and fairness as much as cognition and comprehension. Science instruction that enables consumers to demand and producers to adopt more sustainable practices will require more than simply teaching the “right” answers, and it seems evident that there are barriers to the ability of students and adults to use evidence to consistently reach sound conclusions about food production due to differences in culture and identity. The goal of enabling students to make more informed choices will likely require an expanded understanding of how NGSS practices such as data analysis and argumentation are limited or enhanced by students’ social contexts and backgrounds. In particular, the responses of many of the participants suggest that part of the value of situated learning lies in its opportunities for students to expand their social perspectives and gain increased motivation for evidence-based decision making through personal interactions.

Since ecological sustainability is central to this work, it is being submitted in consideration for Strand 14 (Environmental Education). This paper will also be of value to members of NARST who have interest in communities of practice as a means of motivating students, who have an interest in situated learning that leads to more informed citizen decision making and action, and for those who have an interest in achieving goals specific to rural schools, including sociocultural responsiveness and the closing of achievement gaps between rural and non-rural students.

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