Advancements in Agricultural Development
Volume 1, Issue 3, 2020
agdevresearch.org

Preservice Teachers' Perceptions of Science Integration into Secondary Agriculture Classrooms

N. Conner[1], C. Stripling[2], J. Loizzo[3]

Abstract

After completing a 40-hour field experience course, 26 preservice teachers participated in interviews about their experiences observing science integration in secondary agriculture classrooms. Based on Bandura's social cognitive theory, researchers analyzed interview transcripts for preservice teachers' descriptions of perceived preparedness to integrate science into agricultural education programs based on personal, environmental, and behavioral determinants. Findings indicated the integration of science concepts were reliant upon participants' perceived integration ability, importance of science knowledge, consequences of science integration, application of hands-on learning, practical application of science in agriculture, and the influence of colleague collaboration on the learning environment. From their observations, preservice teachers cited specific instances of academic science concepts relating to agriculture, which they perceived as an applied science. While natural ties to biology and chemistry appeared in classroom lessons, preservice teachers held a belief that agricultural education is a unique practical context for learning and integration of science, but too much science integration is seen as a threat to agricultural education. Many preservice teachers noted the environment surrounding their future agricultural classrooms will play a large role in how they integrate science. Future research should further investigate how behavioral, personal, and environmental factors influence science integration.

Keywords

agricultural education; teacher preparation; social cognitive theory, field experience

1. Nathan W. Conner, Associate Professor, University of Nebraska-Lincoln, 236 Filley Hall, Lincoln, NE 68583-0947, nconner2@unl.edu, https://orcid.org/0000-0003-0063-4110
2. Christopher T. Stripling, Associate Professor, The University of Tennessee, 320 Morgan Hall, 2621 Morgan Circle Drive, Knoxville, TN, 37996-4511, cstripli@utk.edu, https://orcid.org/0000-0002-5045-3492
3. Jamie Loizzo, Assistant Professor, University of Florida, PO Box 112060, Gainesville, FL 32611, jloizzo@ufl.edu, https://orcid.org/0000-0002-5575-2918

Introduction and Problem Statement

Educational reform movements have increased pressure to improve student performance in science, technology, engineering, and mathematics (STEM; National Academies of Sciences, Engineering, and Medicine, 2017; Sanders, 2009). However, agriculture's relationship with the biological and physical sciences has well-positioned agricultural education as a platform for enhancing scientific skills and knowledge (Balschweid & Thompson, 2002; Conroy & Walker, 2000; Enderlin, 1992). Mercier (2015) stated the relationship between science and agriculture is a "seemingly natural connection" (p.11) and agriculture provides students and teachers with a concrete context for STEM concepts (Association for Career and Technical Education, 2006; Dailey et al., 2001).

Science integration in the school-based agriculture classroom gained momentum when the National Research Council (1988) recommended updating agricultural education curricula to include scientific principles and concepts. Today, the American Association for Agricultural Education calls for effective integration of STEM content into agricultural curricula through the adequate preparation of teachers to facilitate the process (Roberts et al., 2016). Prior works have indicated agriculture teachers feel equipped and qualified to integrate science into their curriculum (Osborne & Dyer, 1998; Thompson & Balschweid, 1999). However, Houck and Kitchel (2010) found a large variance in agricultural content preparation for preservice teachers. Floden and Meniketti (2005) found preservice teachers' coursework led to basic knowledge, but it did not provide an adequate understanding of content and scientific process. A deep understanding of content is essential, not only for effective science integration (Phipps et al., 2008), but effective teaching in general (Darling-Hammond & Bransford, 2005). To that end, Ryu et al. (2019) found preservice teachers foresaw future STEM integration challenges and attributed the expected challenges to "school culture and structure, limited knowledge in STEM fields, and an absence of role models" (p. 508). As a result, we seek to understand preservice teachers' perceptions of science integration in secondary agricultural education after observing teacher instruction as part of a field experience course. This information should allow teacher educators to address preservice teachers' perceived knowledge or skill deficiencies, concerns, and misconceptions.

Theoretical and Conceptual Framework

In order to better understand preservice agricultural education teachers' preparedness to integrate science concepts and processes in an agricultural context, it is necessary to examine factors that influence their abilities to do so. Bandura's (1986) social cognitive theory guided the development and implementation of this study. Bandura (1986) described behavior through the framework of triadic reciprocality or reciprocal interactions among behavior, environmental influences, and personal factors. The interacting determinants influence each other bidirectionally, but they do not necessarily interact in a uniformly balanced relationship (Bandura, 1986). According to Bandura (1997), reciprocal interactions are not of equal strength, and one determinant may demonstrate dominance over the others. For instance, personal factors in the triad might outweigh environmental events or vice versa. Although, in most situations, the determinants are vastly interdependent. Furthermore, time is needed for causal factors to exercise their influence, and that time makes it possible for researchers to study or understand the reciprocal causations (Bandura, 1997).

When considering science integration into secondary agriculture courses, the desired behavior would be successful and meaningful teacher instruction. Personal factors may include outcome expectations, self-efficacy (Smith et al., 2015), and perceptions of science integration. Examples of environmental factors that may influence the social environment are interaction and collaboration with peers or other educators, length of teaching career, and certification area(s) (Smith et al., 2015). According to Bandura (1989), individuals have some level of control over their environment. Examining the relationship between perceived future behaviors, personal inclinations and perceptions, and environmental factors influencing preservice teachers could provide insight into preservice teachers' practices related to science integration.

Purpose

The purpose of this study was to explore preservice teachers' perceptions of science integration in secondary agriculture classrooms. Specifically, the following question was investigated: What are preservice teachers' perceptions of science integration in secondary agriculture classrooms after observing teacher instruction as part of a field experience course?

Methods

The epistemological perspective for this study was constructionism in which the preservice teachers construct their own knowledge and meaning (Crotty, 2003). People construct meaning based on their experiences and perceptions, and their constructed meaning may change over time (Crotty, 2003). The theoretical perspective for this study was social constructionism. Preservice teachers construct reality through social interactions. In order to understand reality, individuals must socially interpret and make sense of the phenomenon that already exists (Crotty, 2003).

We used a qualitative approach to interpret the participants' perceptions (Denzin & Lincoln, 1994) and allow for the analysis of feelings and opinions (Creswell, 1998). Merriam's (1988) description of general qualitative methodology informed our study design. Merriam stated qualitative research "simply seeks to discover and understand a phenomenon, a process of the perspectives and worldviews of the people involved" (p. 11). According to Merriam, the generic methodology has become a method of choice in the field of educational research because the method allows for flexibility without confinement to a specific procedure.

We recruited undergraduate agricultural education students enrolled in an early field experience course for preservice educators at the University of Nebraska, Lincoln to participate in this study. The course included a 40-hour early field experience practicum in a secondary agriculture program, in which preservice teachers observed teacher instruction and the classroom learning environment. During the field experience, preservice teachers viewed instruction and environment through Borich's (2015) eight lenses of teacher observation: (a) learning climate, (b) classroom management, (c) lesson clarity, (d) instructional variety, (e) task orientation, (f) student engagement in the learning process, (g) student success, and (h) performance outcomes and higher thoughts processes. Each preservice teacher was required to write two reflective journal entries that included four lenses. Entry one reflected upon lenses a-d, and entry two reflected upon lenses e-h. A combination of university and school learning experiences are commonly incorporated into teacher preparation programs (Childs & McNicholl, 2007). The practicums were conducted throughout Nebraska in rural, suburban, and urban programs. Twenty-six preservice agricultural education students enrolled in the course, and all 26 (24 females; 2 males) voluntarily participated in the study and were freshmen, sophomores, and juniors.

We collected data through two focus groups to bring multiple participants together for collective interviewing and discussion (Berg, 2001). A graduate student external to the research team and with an understanding of agricultural education facilitated the focus groups. We randomly assigned participants to focus groups. Each focus group lasted approximately one hour and was digitally recorded and transcribed verbatim. Data were also collected in the form of the focus group facilitator's observational notes recorded by hand during the sessions.

The thematic analysis method was used to "focus on repeated words or phrases in order to reduce data and to allow themes to emerge" (Grbich, 2007, p. 32). The block and file method was used to reduce the data (Grbich, 2007). The data were color-coded, then grouped into categories, and then chunked into themes. Titles were then developed for each theme, and the data were used as evidence to support the themes.

We followed Lincoln and Guba's (1985) suggested procedures to enhance trustworthiness (credibility, transferability, dependability, and confirmability). Triangulation procedures included comparing data from observation notes to the two focus group transcripts and comparing researchers' codes to enhance credibility. The focus group facilitator verbally member checked understanding and interpretations throughout each focus group to verify the interpretation and meaning of the data and to establish credibility. A description of the early field experience was provided and allows readers to determine the transferability of the findings to another situation (Lincoln & Guba, 1985; Merriam, 1988). Additionally, methodological journaling in the margins of the transcripts helped to link the findings to the data and to increase the dependability and confirmability of this study.

Findings

The following themes were identified: (a) agriculture as a context for science education, (b) hands-on learning experiences are ideal for engaging students and deeper learning, (c) the agricultural education program is a context for practical applications, and (d) colleague collaboration influences the learning environment. These major themes and their sub-themes are presented in the following section and are linked to Bandura's (1986) social cognitive theory from the perspective of a future agriculture teacher and Bandura's three determinates. Participants' names are not used in order to protect identities. The designations of P1-P26 are used as participant identifiers.

Agriculture as a Context for Science Education (Behavioral, Personal, and Environmental)

Integration Ability (Behavioral)

After completing classroom observations, many preservice teachers recognized the ease of which science was integrated into the classroom. Related concepts such as animal husbandry and genetics provided "a natural way to tie [science] in [to agriculture]" (P16). P14 stated agriculture contained a lot of "science-based curriculum." When reflecting in the interview, P15 recognized that "there [are] a lot of opportunities for crossover." P5 stated there are "a variety of different sciences within agriculture" that can be integrated. Science needs to be emphasized in courses because of its direct impact on the entire agricultural industry (P9). Others saw agricultural courses as providing "hands-on experience" (P2), making it "easier to learn" (P2), because the science concepts become "something they can apply everyday" (P3).

On utilizing agriculture as a context for science, many participants were able to pull specific instances of agriculture being used to formulate concrete experiences to strengthen scientific concepts. P11 noted lessons on photosynthesis and plant pathogens occurring in the greenhouse. P2 observed scientific energy concepts integrated by linking them to ethanol creation from corn. P9 related the artificial insemination of a cow directly to biology. P1 noted science concepts were observed through "plant science and soils and genetics and animal science." P8 commented on how agriculture teachers were able to "reinforce those science concepts to further [the students'] understanding of the agricultural concept." Preservice teachers noted these concepts could be integrated into their future classrooms easily.

Importance of Science Knowledge (Personal)

Preservice teachers professed the importance of teachers' knowledge in core science areas. The necessity of having "a broad understanding of all the sciences" in order to teach agriculture was recognized by P8. Because of the bigger role science is playing in the agriculture classroom, P3 stressed how "important [it is] to just have a common background [in the sciences]" to fulfill this demand. P11 noted awareness before classroom observations, stating "I knew I needed to know the basics [of scientific principles]." P10 made note of the importance of understanding science to be able to teach it confidently. In addition, P8 recognized "there's concepts you can't explain without having… at least the core concepts of science and sometimes those don't get covered in the regular science classroom the way they need to, so you need to reinforce those science concepts." That included the general scientific method for P6 who stated, "students know how to set up this stuff for future reference," in reference to scientific experiments. In addition to having a foundation of knowledge, P15 noted the importance of also knowing how to research scientific concepts that might not be retrieved or remembered off hand.

Many of the preservice teachers saw themselves as a resource for potential careers. P1 described this opportunity by stating that agricultural educators could provide a platform for students to “get interested in science” by “making it interesting.” The participant continued by stating that “it’s important those kids even learn the basic knowledge on that… before… deciding on what they want to pursue” because agriculture is “a huge industry.” P3 also believed agriculture classrooms “are so successful because they spark an interest while they are still learning…common things.” P5 backed up these ideals by stating that agricultural educators can spark a broader group of students’ interests.

The benefit of a foundational science course for preservice teachers was apparent to participants, and some went even further to mention that a more detailed education would be beneficial. One participant brought up the idea of obtaining endorsements in biology to aid in agricultural education teaching (P13). Other participants referenced the Curriculum for Agricultural Science Education (CASE) program. P1 recommended not only covering science content in a foundational course, but also including how to connect science concepts to agriculture stating, “the problem is… knowing how to take that and [put] it into [an agricultural context] and teaching it all together” (P1).

P3 raised concern for the need for teacher preparation programs to better teach preservice teachers how to integrate scientific concepts into agricultural education courses. “One thing… that will help me to integrate the science concepts is to use the CASE curriculum” (P8). P11 stated the CASE training “[gives] you a deeper background… in the science and better ways to integrate it.” P7 was able to see CASE in action and felt that it could aid in development of scientific integration. P1 noted that they would love to utilize some CASE curriculum in their future classroom. The CASE curriculum, endorsements, and the ability to learn how to integrate concepts into agriculture courses gave preservice teachers a feeling of confidence in their ability to effectively cover science topics.

Perceived Consequences of Science Integration (Environmental)

Participants voiced concerns that agriculture teaching positions will focus too greatly on integrating science concepts and lose the aspects of what makes secondary agricultural education so important. P12 observed a teacher who taught both science and agriculture courses and saw that “more time and energy [was spent] teaching the core [sciences].” The participant believed that it was going to be a challenge to defend the importance of agriculture classes in secondary schools if it became too focused on meeting scientific standards (P12). P1 noted that it may be difficult for secondary agriculture programs to develop and support additional lab space and equipment needed to integrate more and more general science concepts. Additionally, the participant expressed concern in being able to keep the integrated science interesting and engaging, citing soil specifically (P1). P10 explained secondary agriculture courses are important because they are “an applied science” and their ability to “get kids more active” and stressed students “need to see the agriculture aspect.” P3 observed this phenomenon occurring during their observations. The participant stated “their animal science courses and…the genetic courses and things like that ended up being more like science actual courses instead of…hands-on ag courses. Despite the connections between science and agriculture, participants were worried agricultural education would mimic traditional science courses and budget cuts would lead to the exclusion of agricultural concepts and hands-on learning.

Hands-on Learning Experiences are Ideal for Engaging Students and Deeper Learning (Behavioral)

Within the observed agriculture classrooms, hands-on instruction in the form of projects and labs were frequently observed. For many preservice teachers, hands-on activities were an aspect of agricultural education curriculum that made it stand out and different from other classes (P1, P9, P15, & P12). P2 noted they are a hands-on learner and personally understood the importance of labs and activities which engage students in the learning process “rather than just reading about it in a textbook. P2 also noted “in ag-sized classes you get more hands-on” and “it is easier to learn something when [you are] working and doing it [yourself].” P7 detailed a project observed that allowed students to build a mock production facility, which had to include breeding and genetic information for the species they were breeding. P2 observed test plots that utilized local farmers to teach topics in farm management and plant sciences.

Because of the engaging nature of these activities, secondary students seemed to enjoy the learning process and were more excited to learn. Participants noted the importance of hands-on instruction in agricultural concepts and made a distinction between observed courses that were more engaging because of the hands-on aspects and those that were less interesting because the content was taught in a more teacher-centered manner (P17, P3, & P10). In one observed classroom, P4 saw students “[were] really excited to learn” and that they “want to be in [the teacher’s] class.” P1 shared that sentiment, stating it’s “very beneficial that a student comes into a class excited to learn about it.” This excitement transcends agriculture – P9 reasoned, “If [students] are excited about their agriculture, they are going to be excited about learning science.” Building off that mindset, P11 connected excitement to deeper learning by stating that “they were…excited to apply it and delve into it a little bit more.” Preservice teachers believed integrating scientific concepts into an agriculture course through hands-on activities made students more active and intentional in the learning process.

The Agricultural Education Program is a Context for Practical Applications (Environmental)

A recurrent strategy preservice teachers observed in the agriculture classroom was the application of science in the total program. The interaction between class and laboratory work, supervised agricultural experiences (SAE), and FFA (agricultural education youth organization) activities proved beneficial to student understanding of the importance of foundational science knowledge. Agricultural education, as noted by P11, provides “a way to apply what you are learning” and helps solidify “why it’s important in an area outside of just the typical science structure.” Witnessing science’s applicability to their personal interests “helps [students] with the relevance of it” (P11).

Preservice teachers observed that providing students with classroom instruction accompanied by hands-on laboratory exercises allowed the students to build deeper connections to science concepts. P3 explained that during a teacher observation the teacher spent one day in the classroom going over material and the next day the class would do a lab experiment pertaining to what they had learned. P17 saw similar scenarios play out, stating “they got like a packet at the beginning… then they were supposed to go through and do their reading and then their lab and then fill out their homework on it.” P18 experienced the opposite. P18 observed students collecting leaves outside on school grounds before working in the classroom. Upon return to the classroom, P18 noted the class discussed their leaves with prompted questions such as “what leaf do you think this is, why do you think, which tree does it come from?” (P18). The preservice teachers recognized the importance of bringing context to the agriculture standards.

FFA provided an outlet to develop scientific skills that aided in career development. P2 reflected on a fundraiser where students grew poinsettias. Students were responsible for “tak[ing] care of them, and they [got] to… apply the hormones and fertilizers” (P2). Prior to the hands-on fundraiser, students learned about the processes in the classroom (P2). P1 and P3 observed pH tests and land judging during career development event practices, which provided the students with experience for competing as well as general knowledge that P1 called “beneficial.”

The ability for students to apply concepts learned in agriculture courses at home or in their SAE program was a perceived advantage of integration of science standards. “I’d say genetics is important and a lot of these kids come from farms and stuff and they need to know maybe more in-depth than what they just learn at home,” stated P4. P2 also observed a linkage between the application of scientific, agricultural concepts being used every day stating “they could apply it to something they do every day” referring to their family farming operation. P1 also noted the concepts of soil testing and pH learned in agricultural education classes could be brought home to the students’ farm. By teaching scientific standards in the context of agriculture, preservice teachers found value in the application of those standards on students’ farms.

Colleague Collaboration Influences the Learning Environment (Environmental)

Participants recognized working with colleagues to effectively coordinate lesson plans would greatly enhance the student experience, interest, and understanding. P10 reasoned “if you can work with the science teacher” and “had classes paired together or you could co-teach in class… it would be beneficial for all the kids to see.” P7 agreed, noting it would also be important to “coordinate with other teachers [to] know exactly what level the students are on” so that you “don’t backtrack too much or are way over their heads,” which would make lessons “the most effective.” P7 noted that with collaboration efforts “students get excited that they can actually apply a real-life example that they learned in a different class to like their biology with another teacher so it’s kind of like a realization that what they’re learning in another class matters too.” P1 made note of the strong connection between agriculture and science and noted that students would benefit by being exposed to the information in more than one way. P10 discussed future plans to coordinate with the science teachers to develop lesson plans that incorporate science and agriculture in both courses. The participant believed, if they collaborated with the biology teacher in coordinating lessons, students would see the

https://doi.org/10.37433/aad.v1i3.49

connection between science and agriculture. P10 stated the “kids who might hate that biology class would see how it connects to the applied science and that it can be fun.”

While some preservice teachers witnessed the benefits of collaboration, others noticed the challenges of facilitating this communication, which one preservice teacher called “kind of a balancing act” (P3). P3 observed a miscommunication between the agriculture teacher and science teacher because students in the science courses had already learned a concept being introduced in the agriculture classroom. “[The teacher] said it’s just hard,” noting some students had also already covered topics that were being taught in the agriculture course. The participant continued to voice concern “for the struggle it could be to sit down with other teachers and go through their lessons without bugging them or overloading the students” (P3). P1 stated “it’s definitely going to be a struggle to try [to] talk to the other teachers because sometimes they might take it as offensive,” but that is also reliant on the personality of teachers in the school.

Conclusions, Discussion, and Recommendations

In the context of preservice teacher preparation, the emergent themes can be used by teacher educators to enhance courses and curriculum to better prepare preservice agricultural education teachers. Interactions between behavioral, personal, and environmental factors (Bandura, 1986) play a role in how a teacher chooses to perceive their future integration of science into agriculture courses. Behavioral determinants (Bandura, 1986) manifested themselves in preservice teachers’ perceived abilities to integrate scientific concepts into their future classrooms and the value held in believing the integration of hands-on learning was a natural occurrence that sets agricultural education apart from core academic science courses. Participants were able to cite specific instances and opportunities to integrate scientific standards into secondary agriculture courses highlighting the potentially engaging nature of teaching an applied science. Similar to Mercier’s (2015) assertion, many felt as if integrating science standards with hands-on learning made for an exciting and engaging environment that they would like to recreate in their future classrooms.

The one personal determinant (Bandura, 1986) preservice teachers described was their belief in the importance of possessing and being capable of expressing a broad understanding of science. Darling-Hammond and Bransford (2005) recommended preservice teacher preparation should cover the basics in various sciences. Results similarly indicated preservice teachers believed they are capable of being a resource for their students for a wide range of scientific concepts. Preservice teachers perceived a need to be able to teach multiple sciences. The belief in their ability to integrate science concepts and procedures into agriculture classrooms is consistent with prior research (Osborne & Dyer, 1998; Thompson & Balschweid, 1999). Environmental determinants (Bandura, 1986) appeared more frequently in the conversations with preservice teachers. They held ideas that a lot of what they did in their classroom, as it pertained to integrating science, would be heavily influenced by outside factors. Those factors included the practical applications of agricultural education, perceived consequences of science integration, and colleague collaboration. In indirect ways, preservice teachers made references to the three-circle model of agricultural education, noting that science integration could be influential in the classroom and laboratory, in FFA experiences, and at the student's own farm. The actual design of agricultural education programs and the environment created influences every aspect of a student's education; and holds potential for science to be integrated and applied in various ways. However, despite the ease and naturally occurring instances for science integration, preservice teachers feared that aligning too closely to core academic science classrooms would make it easier for administrative leaders to alleviate budget concerns by cutting agricultural education programs.

In order to better prepare preservice teachers, these observed themes should be considered and addressed through curriculum development for teacher preparation programs. As a result, curriculum should be designed to provide basic understanding of biological and physical sciences (Balschweid & Thompson, 2002) and should have a strong emphasis on connecting science concepts to agriculture (Stripling & Barrick, 2013). We recommend course development should include both the agricultural teacher educator and a representative from the biological and physical sciences. Collaboration would help to ensure quality and rigor, meaningful instruction, and demonstrate positive collaboration that could serve as a model of collaboration for the preservice teacher. Additionally, agricultural teacher preparation programs should create/modify courses to seamlessly integrate secondary science standards into teacher preparation courses. Science integration could occur in stand-alone courses or could be in existing courses that include teaching methods and curriculum design courses. Integrated STEM teaching methods courses such as those proposed by Ryu et al. (2019) and science methods courses should be further explored and studied as potential editions to teacher preparation programs of study. Efforts taken to incorporate science and science teaching methods should improve preservice teachers' abilities to explicitly and intentionally blend science and agriculture into a learning experience that deepens the learner's understanding of each subject (Ryu et al., 2019).

In practice, this study served as a formative assessment of preservice teachers' perceptions of science integration after observing secondary agriculture teachers' instruction as part of a field experience course. Based on the information learned, we recommend future research identify effective agricultural teacher preparation formative assessment strategies, such as the reflective journaling use in this investigation, for science integration to aid in addressing preservice teachers' perceived knowledge or skill deficiencies, concerns and misconceptions. Future research should also continue to examine perceived future behaviors, personal inclinations and perceptions, and environmental factors influencing science integration and seek to determine the most effective way of assessing and preparing preservice teachers to integrate science into their agriculture teaching.

References

Association for Career and Technical Education. (2006). *Reinventing the American high school for the 21st century.* https://files.eric.ed.gov/fulltext/ED524837.pdf

Balschweid, M. A., & Thompson, G. W. (2002). Integrating science in agricultural education: Attitudes of Indiana agricultural science and business teachers. *Journal of Agricultural Education, 43*(2), 1-10. https://doi.org/10.5032/jae.2002.02001

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice Hall.

Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist, 44*(9), 1175–1184. https://doi.org/10.1037/0003-066X.44.9.1175

Bandura, A. (1997). *Self-efficacy: The exercise of control*. Freeman.

Berg, B. L. (2001). *Qualitative research methods for the social sciences*. Allyn and Bacon.

Borich, G. D. (2015). *Observational skills for effective teaching: Research-based practice* (7th ed.). Paradigm Publishers.

Childs, A., & McNicholl, (J). (2007). Science teachers teaching outside of subject specialism: challenges strategies adopted and implications for initial teacher education. *Teacher Development, 11*(1), 1-20. https://doi.org/10.1080/13664530701194538

Conroy, C. A., & Walker, N. J. (2000). An examination of integration of academic and vocational subject matter in the aquaculture classroom. *Journal of Agricultural Education, 41*(2), 54-64. https://doi.org/10.5032/jae.2000.02054

Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions.* Sage Publications.

Crotty, M. (2003). *The foundations of social research*. Sage Publications.

Dailey, A.L., Conroy, C.A., & Shelley-Tolbert, C.A. (2001). Using agricultural education as the context to teach life skills. *Journal of Agricultural Education, 42*(1), 11-20. https://doi.org/10.5032/jae.2001.01011

Darling-Hammond, L. B., & Bransford, S. J. (Eds.). (2005). *Preparing teachers for a changing world: What teachers should learn and be able to do*. Jossey-Bass.

Denzin, N. K., & Lincoln, Y. S. (1994). *Handbook of qualitative research*. Sage Publications.
Enderlin, K. E. (1992). *Student achievement, attitudes, and thinking skill attainment in an integrated science/agriculture course* [Doctoral dissertation, University of Illinois]. Illinois Digital Environment for Access to Learning and Scholarship. http://hdl.handle.net/2142/71916

Floden, R. E., & Meniketti, M. (2005). Research on the Effects of Coursework in the Arts and Sciences and in the Foundations of Education. In M. Cochran-Smith & K. M. Zeichner (Eds.), *Studying teacher education: The report of the AERA Panel on Research and Teacher Education* (pp. 261–308). Lawrence Erlbaum Associates Publishers; American Educational Research Association

.

Grbich, C. (2007). *Qualitative data analysis: An introduction.* Sage Publications.

Houck, A., & Kitchel, T. (2010). Assessing preservice agriculture teachers' content preparation and content knowledge. *Journal of Assessment and Accountability in Educator Preparation, 1*(1), 29-36.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage Publications.

Mercier, S. (2015). *Food and agricultural education in the United States*. https://studylib.net/doc/18802049/food-and-agricultural-educa-tion-in-the-united-states

Merriam, S. (1988). *Case study research in education: A qualitative approach.* Jossey-Bass.

National Academies of Sciences, Engineering, and Medicine. (2017). *Seeing Students Learn Science: Integrating Assessment and Instruction in the Classroom*. The National Academies Press. https://doi.org/10.17226/23548

National Research Council. (1988). *Understanding Agriculture: New Directions for Education.* The National Academy Press.

Phipps, L. J, Osborne, E. W., Dyer, J. E., & Ball, A. (2008). *Handbook on agricultural education in public schools* (6th ed.). Thomson Delmar.

Osborne, E. W., & Dyer, J. E. (1998). Attitudes of Illinois high school science teachers toward educational programs in agriculture. *Journal of Agricultural Education, 39*(1), 8-16. https://doi.org/10.5032/jae.1998.01008

Roberts, T. G., Harder, A., & Brashears, M. T. (Eds). (2016). *American Association for Agricultural Education national research agenda: 2016-2020.* Gainesville, FL: Department of Agricultural Education and Communication.

Ryu, M., Mentzer, N., & Knobloch, N. (2019). Preservice teachers' experiences of STEM integration: Challenges and implications for integrated STEM teacher preparation. *International Journal of Technology and Design Education, 29*(3), 493-512. https://doi.org/10.1007/s10798-018-9440-9

Sanders, M. (2009). STEM, STEM education, STEMmania. *The Technology Teacher, 68*(4), 20–26.

Smith, K. L., Rayfield, J., & McKim, B. R. (2015). Effective Practices in STEM Integration: Describing Teacher Perceptions and Instructional Methods Use. *Journal of Agricultural Education, 56*(4), 182-201. https://doi.org/10.5032/jae.2015.04183

Stripling, C. T., & Barrick, R. K. (2013). Examining the professional, technical, and general knowledge competencies needed by beginning school-based agricultural education teachers. *Journal of Agricultural Education, 54*(3), 67-83. https://doi.org/10.5032/jae.2013.03067

Thompson, G. W., & Balschweid, M. M. (1999). Attitudes of Oregon agricultural science and technology teachers toward integrating science. *Journal of Agricultural Education, 40*(3), 21-29. https://doi.org/10.5032/jae.1999.03021