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Developing Deeper Understandings through an Agricultural Literacy Professional Development

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Abstract

In this study, we examined how the Agricultural Science Professional Development (ACRE) Project, an agricultural literacy professional development, influenced secondary agriculture teachers' agricultural literacy perspectives and practices. We analyzed our data using Moje's (2015) 4 E's Heuristic for Disciplinary Literacy Instruction. Our findings revealed that the eight teachers developed a deeper understanding of agricultural literacies and they planned to apply this knowledge in different ways to scaffold their students' engagement with discipline-specific practices.

Introduction

Much of society today is agriculturally illiterate; people lack the understanding of where food originates before it arrives at the grocery store (Bellah, Dyer, & Casey, 2004; Kovar & Ball, 2013); this is a growing issue in our society as more people are disconnected from production farming such as livestock or row crop farming (Chapman & Lindner, 2018). In fact, it is estimated that the average American citizen is three to five generations removed from the family farm (Brandon, 2012, March 30; Stammen, 2019, August 9; Texas Farm Bureau, 2024) and this lack of agricultural literacy is "a direct result of the transition from a rural to an urban concentration in population" (Elliot, 1999, p. 207). In a systematic review of agricultural literacy studies from 2000-2020, Cosby et al. (2022) found students in high school had overall low levels of agricultural literacy, however, it did vary among regions with rural areas having a higher agriculture content knowledge than urban or suburban.

To address this issue, we created a professional development (PD) on agricultural literacy for secondary agriculture and science teachers. Through teacher professional development, we sought to strengthen and enhance the quality of grades 6-12 agricultural science instruction through in-service teacher PD. The PD was grant-supported, and teachers attended an intensive, in-person, two-week summer institute along with in-person follow-up days during the fall and spring semesters. During the PD, the teachers learned agricultural science, literacy, and teacher leadership content. They participated in hands-on explorations including laboratory experiments, activities, and field trips to the university farms.

Having an agriculturally literate society is essential because all citizens benefit from understanding the economic, social, and environmental significance that agriculture plays in our society (Lewis, 2018). Food production is the basis of all civilization, and global food security is an ever-growing concern with population growth (Howden et al., 2007; Ray et al., 2019). In fact, Ray et al. (2019) posited that crop yields

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have already started being impacted by climate change which impacts the amount of food grown around the world. Therefore, we need a well-educated public to contribute to the success of a safe and affordable food system that will attempt to feed the expected ten billion people in this world by 2050 (Ranganathan et al., 2018, Dec. 5.). In this study, we seek to examine how engagement in the described PD on agricultural literacy for secondary agriculture and science teachers influenced their perspectives and instructional practices related to agricultural literacy.

Conceptual Framework

To situate our work, we view disciplinary literacy as one that is aligned with Moje's (2015) 4 E's Heuristic of Disciplinary Literacy Instruction (engage, elicit/engineer, examine, and evaluate). In this sense, we define disciplinary literacy, which includes agricultural literacy, as the knowledge of and skill with the specialized linguistic codes, technical vocabularies, and discourse practices of a discipline—coupled with examination and critique of those literate practices (Moje, 2007, 2008, 2015). This definition includes the distinct literate practices of the discipline, in this case agricultural science. Moje (2015) proposed there are four dimensions required to teach disciplinary literacy in the K-12 classroom—*engage*, where classroom practices mirror those of the discipline; *elicit/engineer*, where literacy skills and strategies are scaffolded by the teacher; *examine*, where discipline-specific vocabulary is closely examined; and *evaluate*, where the students consider when disciplinary literacy practices are appropriate to engage in or not (see Table 1 below).

Table 1

Moje's 4E Framework

4Es Framework	Definition	Example
Engage	Refers to inquiry-based activities driven by authentic questions that provide a reason for students to read and write within the discipline.	Engaging high school students in disciplinary literacy practices such as animal dissection or learning how to use artificial insemination (AI) rods.
Elicit / Engineer	Refers to what teachers do to develop content-area knowledge and literacy skills.	Scaffolding high school students in the necessary knowledge using content-area literacy / generalizable literacy strategies such as a quick write or Carousel.
Examine	Refers to examining the language used within a discipline, including technical language and discourse practices.	Developing disciplinary discourse / vocabulary words such as artificial insemination and palpation.
Evaluate	Refers to students learning to critically navigate the varied and distinct literacy practices they encounter each day.	Application of discourses to the wider, real-world context such as producing a text for producers.

The 4 E's Heuristic of Disciplinary Literacy Instruction acts as the foundation for our conceptual framework. This heuristic emphasizes disciplinary literacy instruction is an apprenticeship model where the teacher scaffolds the students through disciplinary experiences. However, Moje posited this model can be difficult for both teachers and students since many teachers may be refining their understanding of discipline-specific practices as they work with secondary students.

As an extension of Moje's (2015) 4E's Heuristic of Disciplinary Literacy, we also incorporated Webb's (2002) Depth of Knowledge as a lens in our conceptual framework to look at instructional practices and cognitive load. Webb (2002) identified four levels of depth related to knowledge attainment. The first is *knowledge acquisition*, which addresses recall and remembering facts or steps in a procedure. The next level is *knowledge application*; this level's cognitive load requires students to apply their academic knowledge to a text, topic, or problem. In the third level, *knowledge analysis*, students have a more complex cognitive load because students are required to use reasoning skills to explain their thought processes. Finally, in *knowledge augmentation*, the highest depth of knowledge, students take what they have learned and apply it to a real-world context, like what Moje (2015) details in the *evaluate* E of the 4 E Heuristic.

In using both the 4 E Heuristic of Disciplinary Literacy Instruction and the Depth of Knowledge construct to inform our conceptual framework, we situated literacy through a sociocultural perspective. As such, we subscribe to the thought that literacy is constructed of the languages, practices, and values within a situated, specific community, which in this case would be the discipline of agricultural science (Barton & Hamilton, 2000; Gee, 1996). Through this lens, disciplines are distinct communities bound together by a set of unique literacy practices including reading, writing, language/discourse, thinking, and reasoning (Shanahan & Shanahan, 2008). As such, agricultural science is a community where specific language, tools, routines, gestures, symbols, actions, and ways of doing things delineate it from other disciplines, including other sciences such as biology, chemistry, physics, and geology (Lave & Wenger, 1991; Wenger, 1998).

Review of Literature

In this review of literature, we first present definitions of disciplinary and scientific literacy, based on research. We then share a definition of agricultural literacy and research in this field. We follow this discussion with a review of research on effective professional development.

Definitions

Disciplinary Literacy

Disciplinary literacy is a broad term that encompasses the processes in which individual disciplines read, write, speak, and make sense of texts in that discipline (Moje, 2007; Shanahan & Shanahan, 2008). Habits of mind or practice vary according to each specific discipline. ***Scientific***

Literacy

The term scientific literacy has a contested history in professional literature. Most researchers equate scientific literacy with science plus literacy; in other words, reading and writing in science (Kohnen et al., 2017). This is not surprising as most teachers in the United States are required to take a "reading in the content areas" course (Friedland et al., 2017) where they learn generic literacy strategies that might be implemented in any content area.

Agricultural Literacy

One of the most frequently cited definitions for agricultural literacy is from the National Research Council (1988), who define agricultural literacy as an "understanding of the food and fiber system, which includes its history and current economic, social, and environmental significance to all Americans" (p. 1). Other definitions have been constructed over time including a more comprehensive definition by Meischen and Trexler (2003):

> Agricultural literacy entails knowledge and understanding of agriculturally related to scientific and technologically based concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. At a minimum, if a person were literate about agriculture, food, fiber, and natural resource systems, he or she would be able to a) engage in social conversation, b) evaluate the validity of media, c) identify local, national, and international issues, and d) pose and evaluate arguments based on scientific evidence. Because agriculture is a unique culture, an understanding of beliefs and values inherent in agriculture should also be included in a definition of agricultural literacy so people can become engaged in the system. (p. 44)

Research on Agricultural Literacy

Many studies have examined the implementation of both formal and informal agricultural literacy instruction in the classroom ranging from elementary up to college. Hutcheson (2020) found that fourth grade elementary teachers have a challenging time incorporating agricultural literacy lessons into their daily curriculum, because they are not part of the pacing guide for that grade level. Miller et al. (2022) examined the agricultural literacy knowledge of elementary students (K-5th grade) in Iowa. The researchers used the Longhurst Murray Agricultural Literacy Instrument (LMALI) to assess almost 300 students at Tri-Center Elementary School. Miller and colleagues found that as the students grade level increased, so did their agricultural literacy proficiency. For example, 31 kindergarteners scored at the exposure level (<50%), 18 scored at that level in first grade, and three scored at that level in second grade. This pattern was also evident in the third through fifth grade students.

Ivanitskaya et al. (2002) noted that teaching agricultural concepts in the classroom can enrich a student's understanding of where their food and clothing comes from. Specht et al. (2014) investigated how agricultural literacy and agriculture industry experience influenced students who were enrolled in agricultural communication and journalism courses. The researchers showed the students images from a news story related to livestock production, specifically around the topic of antibiotic-resistant bacteria and the possible link to nontherapeutic antibiotic use in livestock. Overall, the respondents had largely negative responses to the images from the newscast. Based on regression analysis, there was a predictive linear relationship between their perceived agricultural literacy and their reactions to the images shown. Specifically, students who reported that they had higher agriculture content knowledge and were more familiar and aware of issues in agriculture reported more positive scores on the electronic questionnaire instrument than those with lower agricultural literacy levels. This reinforces that someone’s agricultural literacy level does influence their perception of livestock production.

Further, Boix-Mansilla et al., (2000) posited that bringing agricultural topics into the classroom allows students to see the “big picture” and exposes them to topics they might not have considered previously. Additionally, teacher beliefs and experiences influenced teacher planning and implementation of curriculum. Trexler and Hikawa (2001) found that teachers with more agricultural background knowledge and experiences were more apt to bring agricultural experiences into the classroom. Pense et al. (2006) identified that location can play a role in the agricultural literacy knowledge of high school students. In this study, Pense et al. (2006) discovered that the twelfth-grade students in rural Illinois high schools scored higher on the instrument they used that was based on the Food and Fiber Systems Literacy Framework, as opposed to their suburban and urban counterparts.

Dale et al. (2017) assessed the agricultural literacy of Fall 2012 incoming freshman at Oklahoma State University and found that those students who were going to major in an agriculturally related field, and thus were enrolled in the College of Agricultural Sciences and Natural Resources (CASNR) scored statistically higher on the Food and Fiber Systems Literacy instrument than those students who were enrolled in other colleges around the university. Even though the students in CASNR scored a higher mean score than the students in other colleges, Dale et al. (2017) found that the overall mean score on the test was 56%; thus, the incoming freshman population was agriculturally illiterate if passing was considered

70%. While there were studies that addressed the implementation of agricultural literacy curriculum across the grade levels, K-12, most of the formal agricultural education programming occurred in secondary schools (Dyer & Breja, 2003; National Research Council, 1988).

Research on Professional Development

Previous research findings informed the structure and design of the professional development (PD) delivered during this study. Multiple research studies (Avalos, 2011; Borko, 2004; Buczynski & Hansen, 2010; Garet et al., 2001; Putnam & Borko, 2000; Vescio & Adams, 2015) support the understanding that teacher learning is best when supported by PD that includes: intensive workshop experiences outside the school context, followed by meetings during the school year to monitor how teachers incorporate developing knowledge and changes; the creation of strong communities of learners in a collegial environment; close examination of artifacts from the classroom; activities that imitate classroom implementation; and, active learning and engagement during professional development.

Research on effective PD has shown the importance of a community of teachers focused on learning and change. Research findings indicated productive PD fosters dialogic learning and the development of intentional communities that serve to nurture professional discourse (Kohnen & Whitacre, 2017). Buczynski and Hansen (2010) shared that strong professional learning communities (PLCs) were essential in promoting teacher learning and changes to instructional practices. Additionally, Vescio and Adams (2015) noted "teacher collaboration emerged as one way to break the norm of teacher isolation" (p. 276). McLaughlin and Talbert (1993) posited PLCs support the risk taking and productive struggle that go with transforming teaching practices. Van Driel and Barry (2012) shared that teachers benefit from opportunities to reflect on pedagogical changes alone and within a community of learners.

Professional learning communities also bring together diverse groups of individuals with different knowledge and expertise, providing a forum where "community members can draw upon and incorporate each other's expertise to create rich conversations and new insights into teaching and learning" (Putnam &Borko, 2000, p. 7). Ideally, teachers choose to participate in PLCs, developing knowledge and changes to practice over time (Anderson-Levitt, 2002; Coburn & Stein, 2010; Cochran-Smith & Lytle, 1993; Lieberman & Wood, 2003). Successful communities included educational reform networks that apprenticed teachers into their culture through the enactment of specific social practices that built community. These practices included putting teachers at the center, respecting their knowledge, connecting them to peers, and providing them with ongoing support (Lieberman & Wood, 2003). Collegiality and collaboration were key characteristics of these communities, according to previous research.

Professional development that specifically focused on developing a community of learners often included two additional components associated with successful PD: a sustained period and teacher agency. Teacher learning and change in pedagogy is a slow, uncertain process (Buczynski & Hansen, 2010) and significant changes in teaching practice require that teachers have continual opportunities to experiment with implementation and to struggle with new understandings (Guskey, 2002; Keiny, 1994; Strike & Posner, 1992). Thus, "one-shot" professional development has usually not been effective (Garet et al., 2001). In contrast, sustained PD that provided opportunities for frequent collegial interaction and collaboration with fellow educators could enhance teacher learning (Garet et al., 2001; Penuel et al., 2012). Providing the time teachers need to engage in these experiences also empowered teachers to become agents in their own change. Flink et al. (2011) called this "generative professional development;" PD that fostered active participation from teachers who had a vested interest in their own learning.

Methodology

We chose a descriptive case study design because it allowed us to examine secondary agriculture teachers' perspectives and knowledge of instructional practices in agricultural science "within a bounded

system [...] over time, through detailed, in-depth data collection involving multiple sources of information" (Creswell, 2007, p. 73; Yin, 2009). Our case study was exploratory in nature and guided by two research questions: (1) How does engagement in an agricultural literacy professional development influence secondary agriculture teachers' agricultural literacy *understanding*? (2) How does engagement in agricultural literacy professional development influence secondary agriculture teachers' agricultural literacy *instruction*?

Participants

After receiving Institutional Review Board (IRB) approval, we sent out recruitment information for our PD through social media and school administrations. We opened recruitment to grades 6-12 science and agriculture teachers in our state. The potential applicants completed an application process including the initial application and a commitment letter, which detailed the PD requirements and required both principal and teacher signature. Once we received the commitment letters, we reviewed applicants and selected 12 teachers for our first cohort.

We conducted this specific study with a subset of PD participants selected above; specifically, participants in this study were the 8 secondary agriculture teachers who were certified to teach agriculture in Mississippi. Their teaching experience ranged from one year to over twenty-five years, and they were located in different areas of the state (see Table 2).

Table 2

Agriculture Teacher Participants

Pseudonym	Race (self - identified)	Gender (self - identified)	Years Teaching	Educational Background	Geographic Location in MS
Fred	African American	Male	4	Bachelors	East Central
Kevin	White	Male	5	Bachelors	Central
Ashley	White	Female	9	Masters	West Central
John	White	Male	2	Bachelors	Southwest
Wesley	White	Male	26	Masters	East Central
Bennett	White	Male	1	Bachelors	North Central
Alex	African American	Male	8	Bachelors	West
Walker	White	Male	1	Bachelors	East Central

Research Context

The teachers participated in an intensive two-week summer institute at a land-grant university campus. During the two-week institute, participants received hands-on instruction related to animal science, plant science, and meat science, as well as teacher leadership and literacy integration. They also took field trips to the university dairy, north farm (plant and soil science research facility), south farm (livestock research facility), and learned about processing animals for consumption—from farm to fork—at the meat science lab. Specific agricultural science topics included: 1) developmental programming, 2) reproductive physiology, 3) lactation, 4) immunology and disease, 5) forages, 6) thermal imaging, 7) farm management, 8) meat science, and 9) importance of plants to combat plant blindness. Specific disciplinary literacy concepts included reading and writing science/technical texts and language/vocabulary development. Moreover, the teacher leadership component focused on topics such as ethical practice, reflective practice, and communication, forming collaborative relationships, and technology integration.

All the specific topics were taught through lectures and hands-on applications, either with application problems, experiments, or labs pertaining to the agricultural topics. Hands-on practice for strategy implementation (e.g., magnet summaries, carousel, quick writes) with agriculture texts (e.g., Mississippi commodities texts from Farm Bureau Foundation and Mississippi State Extension) and strategy handouts were also included, as well as group and individual work around the teacher leadership topics. For example, when the teachers learned about physiology, they dissected a fetal pig. For developmental programming, the teachers learned how to palpate and ultrasound a beef cow at the livestock research facility. The teachers all received a binder full of lesson plans implemented during the PD and access to the PowerPoints covered in lectures. Teacher participants also received a strategy book (e.g., *But I'm NOT a Reading Teacher! Literacy Strategies for Career and Technical Educators* [Adams & Leininger, 2017]) to help them implement a wide range of literacy strategies into their own agriculture instruction for the upcoming school year.

Teachers were required to create one agricultural literacy lesson plan, which they implemented in the fall semester following summer institute at the local school sites, and to disseminate this resource to district peers as well as to summer institute teacher participants. Further, teacher participants came back to the university for a fall and spring follow up day in which they learned more information about agricultural science including greenhouses, lambing, FAMACHA scoring, forestry and timber management, equine therapy, wildlife management areas, and application of herbicides, fungicides, and pesticides on row crops. The teachers self-evaluated their own learning throughout the institute and follow up sessions. They completed reflections on many of the topics and participated in pre-post-delayed post interviews and pre-post-delayed post surveys.

Data Sources and Analysis

Data sources for this study included the PD application form, a participant-created lesson plan from PD content, a participant-created lesson plan from their fall semester, reflections from the summer institute, pre-post-delayed-post-interviews, and pre-post-delayed-post survey data. Specific sections of the application form included: educational background (e.g., college major and minor, highest degree obtained), teaching background (e.g., school/district, grades/courses expected to teach during the upcoming school year, number of years teaching current courses, number of years teaching agriculture content, if any), agriculture background (Have you ever worked in an agriculturally related job? If so, when and for how long?), accommodations (e.g., CEU, dorm, specific accommodations-COVID related, disability, etc.), and three open-ended questions sets (1) Describe yourself as a teacher. What are some of your strengths, and what are the teaching areas you struggle with the most? 2) Why do you want to participate in the [PD] this summer? What do you imagine will be the biggest benefit of the program? 3) What is your relationship with/what are your experiences with agriculture?).

Participants completed multiple reflections during the 2-week institute sharing their thoughts in response to experiences. The pre-post-delayed-post interview questions focused on specific strategies the teachers previously used in their classroom instruction and what strategies they learned at ACRE they planned to implement. Survey data provided additional insight into their planning for the fall.

Data analysis was completed in an ongoing manner, with each analysis level identifying the next step for data collection (Yin, 2009). This procedure was influenced by previous work with elementary and secondary disciplinary literacy perspectives and practices (Lemley, Hart, & King, 2019; Lemley & Hart, 2018; Bennett & Hart, 2015). Throughout this process we relied on multiple forms of triangulation to strengthen our findings. First, we utilized data triangulation because we analyzed multiple data sources over the course of the summer institute to construct our findings (Stahl & King, 2020). To analyze the data, we used Saldana's (2021) recursive levels of coding, identifying themes and patterns that were next organized into concepts to share findings. First, we coded individually for agricultural teacher understandings and beliefs about agricultural literacy pedagogy and practice using codes from relevant literature –basic (e.g.,

foundational literacy skills), intermediate (e.g., generic reading and writing strategies that can be used across content-areas), and disciplinary literacy (e.g., discipline-specific practices that are unique to a given discipline) levels as framed by Shanahan and Shanahan (2008) and Moje's (2008) framing of content knowledge and discourse to generate a broader understanding of their evolving beliefs and practice on agricultural literacy.

We next engaged in a deeper level of analysis by coding for Moje's 4E Framework (Moje, 2015). We did so because her framework provided an interesting view of literacy, which focuses on authentic practice. Therefore, we looked at each teacher and how they enacted the 4 E's from the framework in the data sources they provided. Thus, our cases included a) Engage, b) Elicit/Engineer, c) Examine, and d) Evaluate. In our analysis, we used Moje's definition for each of the codes. Additionally, the use of multiple coders allowed us to establish interrater reliability (Stahl & King, 2020).

To establish interrater reliability, we conducted the first iteration of the 4E coding independently, subsequently met to collaboratively analyze the total within the 4E framework and discussed discrepancies to reach agreement. Interrater reliability checks were conducted where we confirmed our coding process as we continued to code the remaining data. Once we reached interrelater reliability, we constructed profiles of agricultural literacy practices (see more information in Results) illustrating their implementation of such practices based on Moje's (2015) 4E framework. Then, we constructed specific case studies of three of the eight teacher participants who were selected because they served as a good representation to further illustrate our profiles of our teacher participants.

Findings

Two findings emerged from the data analysis, described below. We discuss findings for all eight agriculture teachers in our first finding and in our introductory paragraph of the second finding. Next, we present three profiles that represented the 8 teachers agricultural literacy practices doing so to highlight the progression of agricultural literacy practices exhibited by our teachers based on their implementation of Moje's (2015) 4 E's Heuristic of Disciplinary Literacy Instruction. These three profiles are first presented at the beginning of the second finding and expanded on using three case studies in the second. Collectively, the three participant cases illustrate the range of agricultural literacy practices exhibited by our 8 teachers in this study.

Finding 1: Lacking the "Literacy" in Ag Literacy

All eight teacher participants recognized the importance of agricultural literacy and provided definitions of what it meant to be agriculturally literate in both their pre-institute interview and post-institute interview. Primarily, their definitions were focused on individuals' understandings of the food and fiber systems. For example, John noted that agricultural literacy is "[the] need to be able to understand and explain how day to day life could not function without agriculture industry as a whole in relation to like food products and fiber products on meat production, plant production." This definition, which was provided prior to the summer institute, was not much different than the definition John provided at the end of the summer institute, that agricultural literacy is "understanding [the] multi-faceted area of agriculture, food, fiber, shelter, all those aspects, and how they are intertwined into society."

Rarely did participants' explanations of agricultural literacy involve the physical literacy characteristics of reading, writing, speaking, and thinking like an agriculturalist. Bennett was one of the only agriculture teachers who's pre-and-post interview definitions discussed the importance of knowing "agriculture terminology" as part of being agriculturally literate. Walker highlighted the importance of "know[ing] the basics of the agriculture [sic] that surrounds you, that can be anything from terminology out of the way to where your food comes from." However, this notion of vocabulary was absent from his post-institute definition of agricultural literacy.

Interestingly, based on the survey data, the teachers thought they would do well explaining literacy concepts to their colleagues around the idea of reading, writing, thinking, and interrogating texts like an agriculturalist though they did not share these details themselves. Specifically, when asked "On an assessment where I had to provide an explanation to teachers at my grade level on how to teach discipline specific vocabulary I would score," the average response was 80-89%. This was a trend that was evident across all the literacy items provided in the post-survey assessment. The teachers were asked about teaching vocabulary, how to read a text like an agriculturalist, how to interpret nontraditional texts (e.g., charts, diagrams) like an agriculturalist, to write like an agriculturalist, and to think like one.

Further, 50% of the teachers acknowledged that they have had their students engage in reading the textbook in class on a routine or daily basis. On the post survey, the teachers listed a variety of literacy strategies they learned about at the summer institute that they planned to incorporate into their classroom instruction to help their students read, write, and speak like agriculturalists, including carousel (37.5% of teachers), mind mapping (62.5%), quad /affinity concept maps (62.5%), and quick writes (25%). However, while they acknowledged the importance of literacy strategies and practices, results from the post survey and the delayed-post survey indicated most of the teachers found the hands-on activities and farm visits to be the most beneficial aspects of the PD and the focus on pedagogy and/or literacy strategies to be the least beneficial. On the delayed post, the most frequently mentioned literacy strategy implemented in classes was the carousel strategy where students recorded all they knew about a topic on a piece of chart paper and rotated around the room addressing a variety of topics.

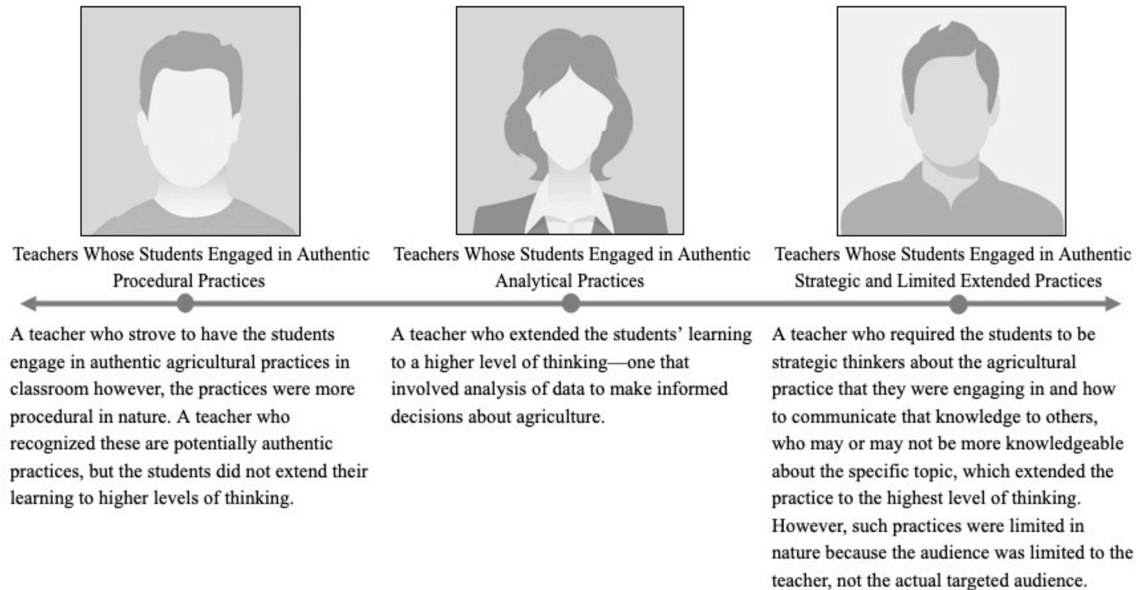
Finding 2: How the Agricultural Literacy PD Influenced Ag Teachers' Instructional Practices for Agricultural Literacy

Results indicated all eight teachers showed an increase in their recognition of the distinct literacy practices associated with the agriculture discipline. Findings also demonstrated an increase, although limited, in the quantity of disciplinary- and content-area literacy instructional practices the teachers planned to implement. In participant-constructed lesson plans, all teachers planned to have their students *engage* in many hands-on, everyday practices of the discipline, such as learning how to use cattle artificial insemination (AI) equipment, identifying the best type of soil for particular plants, and analyzing how soil texture and composition affect soil erosion. These practices are used by animal scientists, producers, and plant and soil scientists frequently. Thus, these authentic experiences, which would require students to use appropriate disciplinary terminology while engaging in those practices, allowed teachers to promote their students' *evaluation* of the contextual and purposeful uses of disciplinary discourses.

Furthermore, teachers, as evidenced by their lesson plans, reflections, surveys, and interviews, planned to implement scaffolds to *elicit/engineer* agricultural texts and terminology with their students. Some teachers also planned to have their students *examine* discipline-specific vocabulary. Finally, all teachers discussed how they planned to have their students read more informational texts on agriculture topics. In our analysis of the data including teachers' lesson plans, we created three profiles based on participants integration of agricultural literacy within authentic practice (see Figure 1). These profiles represent the range of integration amongst our teacher participants, from engaging their students in authentic practices that were more procedural in nature, to engaging in practices that required analysis and higher-level thinking, to engaging in practices that required students to be strategic thinkers who could communicate knowledge.

Figure 1

Profiles of Authentic Practice



Teachers Whose Students Engaged in Authentic Procedural Practices

Specifically, when looking at data analysis for all eight teachers, we found that three teachers (e.g., John, Walker, and Bennett) engaged their students in authentic practices that were *procedural* in nature. These practices did not support students' extension of learning to higher levels of thinking. For example, both John and Walker focused their lessons on livestock reproduction. However, they kept their activities focused on the procedural nature of learning how to use the rod to artificially inseminate (AI) a fake reproductive tract. In his lecture, John touched on the history of AI in the livestock industry as well as the equipment used for AI; however, he did not have his students extend their thinking to consider the ramifications of the industry if AI was not used, for example. The third teacher, Bennett, produced a lesson plan that included little student interaction as they worked on a task an agriculturalist would engage in. He had his students feel three types of soil and then Bennett demonstrated in the lab how slope, texture, permeability, and runoff affected erosion. As such, all three of these teachers wrote lesson plans on topics that they recognized as authentic practices; however, there was a lack of content depth beyond procedural knowledge provided to students in the lesson plans.

Teachers Whose Students Engaged in Authentic Analytical Practices

In contrast, four teachers (e.g., Fred, Ashley, Wesley, and Alex) all had their students engage in *authentic analytical practice*, in this case the soil lesson. Each teacher used a soil lesson we provided them with and that they had completed in the summer institute. In this lesson, their students assessed water percolation in different soil types, deciding which soil was best to use when potting plants. Teachers had their students use higher order thinking skills (e.g., analysis and evaluation) to make decisions about soil types.

Teachers Whose Students Engaged in Authentic Strategic and Limited Extended Practices

Finally, one teacher, Kevin, engaged his students in *authentic strategic and limited extended practices* in the classroom to support their learning and to communicate their knowledge. In his lesson, Kevin's students practiced AI rod insertion in a real reproductive tract he secured from the university.

Further, to reinforce terminology, Kevin had his students write to knowledgeable others about the topic which *limitedly extended* the students' knowledge about AI because the students had to make real world applications in a new situation. We acknowledge this is *limited extension* because the final product was never distributed outside of the classroom.

Case Studies of Three Teachers

We now present case studies for three of the teacher participants as exemplars represented by the three profiles, illustrating the diverse ways all eight teachers utilized agricultural literacy practices to design and deliver agricultural literacy instruction in their high school classrooms.

Walker: Limited Eliciting/Engineering and Limited Engagement in Disciplinary Practices

Walker taught Concepts of Agriscience and Plant Science at his high school. Walker had a bachelor's degree in Agricultural Education. In his pre-interview, he defined agricultural literacy as "means to know the basics of the AG that surrounds you, that can be anything from terminology out of the way to where your food comes from." In his application to the program, he noted that he was "a very outgoing teacher" but he struggled with "being able to explain things to my students." He wanted to participate in the PD because he wanted "to improve his teaching skills and methods and get more hands-on experience."

In his pre-interview, Walker admitted that he does not use any literacy strategies with his students to access agricultural texts, but he does use "a lot of online scientific research papers" with them. In his application, Walker described himself as one with "somewhat limited experiences with agriculture." Growing up, he raised chickens, gardened, and was a member of FFA. He noted that serving as the FFA advisor at his school has taught him a lot. Specifically, he explained, "I have learned how to manage a beef cattle herd through working with my co-teacher this year. I never showed livestock, so I have also learned the basis for which animals are judged and the qualities and characteristics it takes to be both a good judge and showman."

In his application, Walker said he also struggled with providing his students with "fun experiments and activities" related to the content. Thus, in his lesson plan he produced from the summer institute, he focused on providing that hands-on experience with his students, through both a fetal pig dissection and through learning about artificial insemination (AI) and practicing it in a female reproductive tract he received at the summer institute. Thus, Walker recognized authentic practices—dissections and AI; however, he did not extend this learning past rote memorization of learning to pass the AI rod through the fake reproductive tract that was supplied to him at the summer institute in his materials. Thus, his students engaged in *authentic procedural practice* because his focus was to solely to teach his students the procedures to AI livestock. His lesson plan did not require his students to extend their learning past the lesson of the day to consider how AI might impact livestock reproduction and the livestock industry. Nor does Walker have his students engage in the communication of their knowledge of AI with others, which would require them to deliberately consider how they would communicate about AI with insiders or outsiders to the industry.

While Walker was excited about the different literacy strategies presented in the summer institute, and indicated in his post-survey that he wanted to use the "stop and talk strategy with agricultural texts, […] as well as read alouds and a focus on using correct terminology in the classroom, Walker's incorporation of literacy strategies was limited in nature, focusing on the Carousel and exit tickets as illustrated in both of his lesson plans on breeding methods and reproductive systems in cattle as well as his delayed post interview. In one of his reflections, he noted that he "liked the idea of having the students ask me a question as an exit ticket. […] I would take some of the best questions and have my students investigate an assigned question and we will discuss them as a class." In his delayed post interview, he mentioned the Carousel was used as preassessment in his class. Exit tickets were also used in one of his lesson plans on

animal breeding. Further, in the delayed-post interview, he also had used a think-pair-share strategy and popcorn reading strategy with his student; think-pair-share was shared with the teachers at the summer institute; however, popcorn reading was not.

On his delayed-post survey, Walker indicated that while he taught ag science concepts daily, he occasionally used hands-on strategies or had his students engage in hands-on learning with experiments or other laboratory experiences. Instead, he routinely had his students read their textbook and complete worksheets on the materials they read.

Ashley: Moving Towards Engagement with Some Eliciting/Engineering to Learn More About Agriculture Disciplines

Ashley taught multiple agriculture classes at her high school including Concepts of Agriscience, Animal Science, Plant Science, and Environmental Science. Ashley had a masters in Agricultural Education and an undergraduate degree in Agricultural Information Systems. In her application, she noted that she tried to stay current in the discipline of agriculture by working at a local agricultural equipment/supply company in the summers. In her pre-interview, she noted that she believed that "ag literacy is very important" and that

> so many people have no idea where their food comes from [….] no idea where their clothing comes from, they think, or they have in their mind, like an idea of agriculture that was from 1940 or something, standing behind a plow, while walking out in the field, they don't realize what agriculture is involved and all the different areas. That here is in our culture in their minds. They just think [of] a farmer.

Ashley emphasized that as part of her instruction she tries to show her students all the different options they have in agriculture as a field. She explained,

> [The students] don't know about, like horticulture […] of like wildlife management and things like that in agriculture, um, some of the things under the umbrella. So, I think it is important that they know what it is because number one they need to know where their food comes from number two, they need to know what all is out there. There's a lot of different areas that can go in.

Ashley believed that she was fortunate because her classes allowed her to be "more progressive and do things with them that other teachers can't." In her classroom, she strives to connect her students with all areas of agriculture. She noted that because of where her students live, "agronomy is of a big interest to them" however, she struggles with "connecting the kids to the material" especially if it is not plant science. Part of Ashley's instruction included using the FFA New Horizons magazine because her students could "see kids from other schools, and they get to read about what they're doing and stuff, even though it's not really something classroom based." She also used the internet a lot in class to have them look up things that were of interest to them. In her pre-interview, she opened her cabinet behind her desk and noted that the textbooks in there were useless because they were "outdated-they're like 20 years old and we cannot use them anymore" so she resorted to other types of text in her classroom instruction. Ashley did not use any literacy strategies with the texts in her room though. She spoke about having her students read the texts, which helped them "not look […] at a phone […] or harass […] somebody on Snapchat. This is great."

During the summer institute, Ashley became more open to incorporating literacy strategies into her instruction. In the lesson plan she wrote for the summer institute, she incorporated the Carousel, a strategy that encourages productive talk and discussion in the classroom. In this lesson, she had her students investigate careers in agriculture. She placed ten sheets of chart paper around the room with different agriculture disciplines on them (e.g., animal science, plant science, agriculture communications, agriculture business, food science, agriculture mechanics, etc.). Then groups of students would write what careers they knew about that fit in those disciplines. Once the students brainstormed their prior knowledge, they would use the Internet to do more research around these topics and add to their charts. In one of her reflections from the summer institute, Ashley wrote,

I have gotten a lot of great ideas to implement in the fall. One, the Carousel activity I am very excited to use. The think-pair-share ideas and the ranking of vocabulary words by importance are all things I plan to use. I plan to use the Carousel activity with the Ag Career clusters. I am going to write each area of ag on a sticky note and let them name as many jobs as they can.

In her post-interview, Ashley noted that the Carousel was her favorite strategy that she learned during the two weeks.

However, Ashley's implementation of literacy strategies was limited to the Carousel strategy, and it was only used in her classroom with the agricultural careers lesson plan she submitted at the summer institute, even though she noted that her "students responded to it a lot." Instead, she focused much of her instruction on implementing hands-on activities with her students that mirrored more disciplinary practices in the field. For example, in her fall lesson plan submission she had her students take soil samples and determine which soil type would be best for what plant. Ashley mentioned that plant science was an area she wanted her students to explore more because of the area of the state in which she resided.

Ashley focused on having her students *analyze authentic practices* in her classroom. In her plan her students calculated soil percentages and assessed water percolation in different soil types. This analysis required higher other thinking skills and was similar to what soil scientists might do daily. In her delayed-post survey, she noted that she routinely has her students engage in hands-on learning in her classes; she did not mention any other literacy strategies that she used with her students throughout the year, other than the Carousel strategy at the start of the year with the careers lesson plan.

Kevin: Engineering, Examining, and Evaluating to Engage in Authentic Disciplinary Practices

Kevin taught multiple agriculture classes at his high school including Animal Science, Plant Science, Concepts of Agriscience, and Agricultural Mechanics. Kevin had an undergraduate degree in Agricultural Education and worked as a research assistant in the university's plant and soil science department while earning his degree. He also previously owned a small landscaping business and made regular farm and industry visits in his local area to "educate [himself] about current industry trends and standards." In his pre-interview, he defined agricultural literacy as "to know where your food [...] your fiber, your clothes, and your shelter [comes from]. I think you need to know the industries that provide the services and provide products for us." He prided himself on being a teacher who "promote[s] hands-on learning and encourage[s] real world application in my instruction."

While he provided his students with lots of hands-on instruction, Kevin admitted he did not use a lot of literacy strategies with students to help them access text. The strategy he most frequently used was summary writing for Future Farmers of America (FFA) magazine articles. However, as the institute went on, Kevin's incorporation of literacy strategies changed, evidenced in his reflections. In one reflection Kevin noted the importance of vocabulary in the agriculture classroom. He posited, "I need to incorporate more vocabulary in my teaching. Students need to know and understand terminology so they can refer to it when discussing class content and engaging in activities. I can use a magnet summary to define more complex terms or concepts." In his post interview, Kevin noted he plans to use "mind mapping because there are some terminology the kids don't really grasp" and he believed it would be a useful strategy to help students understand the terminology.

While Kevin's stance on literacy incorporation changed over the course of the institute, it did not do so to the detriment of the incorporation of authentic disciplinary practices in his instruction. Rather, Kevin saw ways he could provide his students with techniques to learn disciplinary terminology more successfully using articles and strategies, which could then be applied to hands-on, authentic disciplinary practice. Specifically, in his lesson plan he wrote for the summer institute, his students learned how to artificially inseminate (AI) beef cattle reproduction tracts while mastering reproduction terminology.

Kevin made *strategic* choices for his instruction to *implement authentic practices* with his students. After the hands-on reproductive physiology lesson at the livestock research facility on campus where the teachers learned how to insert an AI rod into a thawed reproductive tract, about ultrasonography and how to palpate to detect pregnancy, Kevin had secured a frozen reproductive tract, from one of the animal scientists co-PIs on the grant, to use with his students. He also had fake reproductive tracts and AI rods to use with his students; these supplies were provided through the PD grant funds to the teachers.

Kevin also incorporated a publication produced by the state cooperative extension service in his plan for his students to learn more about the topic and as an assessment he had his students write out the directions on how to AI for a producer. This authentic practice required the students to provide precise directions utilizing proper terminology, which caused them to examine the language used in the procedure as well as evaluate when the technical language is appropriate to use and when it is not. Students were required to assess how technical/scientific they should be in their description of AI for producers. Further, he had his students practice artificial insemination on authentic reproductive tracts from one of the Animal and Dairy Science faculty members associated with the professional development. This allowed the students to engage in a real life practice that producers engage in with their beef and dairy cattle-- artificially inseminating a heifer or a cow herd. It was *limited* in *extending* their learning and thinking because they had to apply their new knowledge to a different situation—preparing AI procedures for producers however those procedures were for a school assignment; Kevin never shared them with the authentic audience.

In his classes throughout the school year, Kevin continued this idea. In his delayed post interview, Kevin noted how he used the Carousel and the mind mapping strategies to help his students learn about the content. In the delayed-post survey, he wrote, "I used the Carousel activity to teach domain-specific/discipline-specific vocabulary" and Kevin shared that the mind mapping strategy was used to help students unpack misunderstandings related to "antibiotic and hormone use in livestock." In the delayed-post interview, he described how he had his students, "perform research to create a mind map and share their findings with the class." In this experience, Kevin had his students use industry publications, such as Extension publications, to help them clarify their misunderstandings on the topic. On his delayed-post survey, Kevin noted that he routinely used hands-on learning in his classroom and his students engaged in hands-on experiments or other laboratory activities daily or almost daily. Kevin rarely had his students read their textbook and complete worksheets about the topics; instead, he viewed himself as the "shop AG Mech guy, hands on guy." At the end of the school year, Kevin wrote to the team, "I just wanted to commend you for your efforts on the […] program this year, as it has been the most beneficial and content related professional development opportunity that I participated in thus far."

Discussion

As this research focuses on eight agricultural education teachers in one state, there are some limitations to the study. First, these findings cannot be generalized to the larger agricultural education teacher population. If more agricultural education teachers went through the same year long professional development as these eight completed, the results would not be the same. Second, this study represents one year in these teachers' teaching career—this is one small part of their teaching story. As such, caution must be exhibited when generalizing findings. However, this study does shed light onto agricultural literacy practices in high school agricultural education classes. Therefore, it adds to the specific knowledge base regarding disciplinary literacy in agricultural science.

This study is significant because this knowledge base is limited (Lemley & Hart, 2019). Much of the work on disciplinary literacy in science is in general sciences classes such as physics and chemistry (see Choi, 2023; Rainey et al., 2018). Agricultural literacy is a disciplinary literacy; agricultural science is a discipline in its own right, and within this discipline there are sub-disciplines as well (e.g., plant science, animal science, meat science, etc.). Through this work along with other research we have presented

(Lemley, Alley, & Clary, 2023), we argue that the conceptualization of agricultural literacy should be expanded to include not only the content knowledge specific practices unique to the field, and that the reading, writing, and discourse practices utilized in the field should also be valued as part of what it means to be agricultural literate. Furthermore, these practices must be emphasized in agricultural education classrooms.

Based on our understandings of what it means to be agriculturally literate, which we acknowledge includes encompassing those distinct reading, writing and discourse practices as well as the content knowledge practices (e.g., AI, soil testing, etc.), we have some interpretations regarding our teachers and their implementation of agricultural literacy practices based on Moje's (2015) 4E's. First, we posit background knowledge of the teachers may have contributed to the development of their disciplinary literacy understandings and engagement in authentic disciplinary practices. Having completed an undergraduate degree in agriculture education or an agriculture field may have provided all the teachers with experiences to have their students engage in authentic disciplinary practices. Further, other life experiences, as noted on their PD applications and their interviews, could have provided the teachers with more knowledge to have their students engage in "authentic" disciplinary practices. These experiences included second jobs (Ashley), research opportunities (Kevin), and working with more seasoned colleagues in an experienced/novice teacher model (Walker).

In our case studies of the three example teachers, each wrote lesson plans detailing engagement in authentic disciplinary practices such as soil composition analysis and artificial insemination (AI) of a reproductive tract. A big emphasis for all the teachers was Moje's first E-engage. For example, Ashley's soil lesson plan focused on collecting soil samples as a soil scientist, producer, or row crop farmer would do, required her students to engage in inquiry, posing questions, studying data, and synthesizing their findings to discover which type of soil is best for planting certain plants. Likewise, Walker had his students engage in a disciplinary practice of AI, but it was limited to classroom experience; it was not applied to a larger authentic context.

Only Kevin tried to extend this authentic engagement to Moje's final E—evaluate. Specifically, he charged his students with the task of writing out AI procedures for producers. As part of this requirement, Kevin's students had to evaluate how much scientific and technical terminology they should use; producers typically do not use as much scientific and technical terminology as an animal scientist would; however, they do have some knowledge of technical terms that go beyond the public (personal communication, Nov. 9, 2022). In fact, the reproduction tract and the AI focus was one that all three of our eight teachers focused on for their lesson plan from the summer institute. We hypothesize that this is the case because this activity was done at the summer institute and made a significant impression with the teachers. Specifically, in his post-institute interview, Kevin said, "I got some of the repro tracks from [reproductive physiologist on the grant]. I'm excited to use those. The kids will think they're gross, but it'll be fun."

The reproductive physiologist in the animal science department (a Co-PI on the grant who taught the anatomy and physiology and reproduction content) had the teachers "preg check" at the livestock research facility. Further, he supplied the teachers with fake reproductive tracts and AI rods to use with their students as well as frozen reproductive tracts to take home to use with their classes if they were interested.

While we would argue that all the teachers tried to emulate authentic disciplinary practices, they were doing so in the restricted environment of school (Windschitl, 2019). Even Kevin's focus on writing out the AI steps for producers was restricted in the sense that the students were doing it for a school assignment; he did not extend the assignment to have students produce a written communication piece for real life producers. Thus, we will now expand on Figure One, referenced earlier in the Findings section (see the first paragraph of Finding 2), illustrating how all of the teachers were implemented various levels of authentic agricultural practices based on Moje's (2015) 4E's framework.

In our profiles which illustrate levels of authentic agricultural practice, we recognize that three of the teachers (e.g., Bennett, John, and Walker) had tasks that were more at the recall/recognition/limited application level. For example, in Walker's lesson, students acquired knowledge about AI and dissection through activities that allowed them to engage in the defined, specified procedures, but the lesson stopped there. As such, much of his focus was on the learning of factual knowledge—such as terminology or specific details about the fetal pig (Krathwohl, 2002). Even the dissection, which would be an application cognitive level, involved following procedures already established in the lab manual. Regarding cognitive practices, Walker focused on lower levels; if he had had his students classify organs in the fetal pig into systems or explained to each other how an AI rod helps increase the likelihood of pregnancy, Walker could have extended the cognitive process dimensions to a higher level such as understand (Krathwohl, 2002). Further, we recognized that four of the teachers (e.g., Alex, Ashley, Fred, and Wesley) moved above rote memorization and limited application to the higher order thinking skill of analysis. For example, Ashley tried to have her students apply and analyze data to make informed decisions about the best soil type to plant specific plants. She required her students to execute procedures in the soil lab but extended the objective to include analyzing and evaluating diverse types of soil to make the best-informed choice as possible. These practices required a higher cognitive load than what Walker had his students do in his classroom (Krathwohl, 2002).

Finally, one teacher was strategic and tried to extend his lesson to have his students engage in the highest levels of thinking with the creation of knowledge in new situations. Kevin had his students engage in strategic thinking and even worked towards the students extending that thinking to a higher level. Specifically, he had his students engage in creation, which is the highest level of cognitive process. His students were required to generate a piece of writing on AI for 'producers,' which required many of the lower cognitive levels such as following lab steps (e.g., remembering and applying) but also were extended to the create, which requires the highest cognitive load (Krathwohl, 2002). However, we acknowledge that this extension was not perfect because it ultimately because an extension that was shared only in class with him, not the producers in the field.

Second, we think some of the agriculture teachers' ability to transfer these disciplinary practices into more authentic experiences was influenced by their own disciplinary backgrounds. We posit that a strong disciplinary background ensures content knowledge, and, in this case, the discipline helped some teachers develop pedagogical content knowledge (PCK) and better understand how to teach the disciplinary practices to others. Specifically, Ashley and Kevin had strong disciplinary backgrounds plus multiple years of teaching experience and other life experiences that helped them learn more about the agriculture discipline. These experiences may have helped them implement more authentic practices into their own classroom instruction. Walker, however, had limited agricultural experience before entering the classroom. As a novice teacher, he might not have had the knowledge to implement more authentic practices that went beyond recall and memorization (Webb, 2002).

Regarding the lack of literacy instruction occurring across the three classrooms, we posit that two of the agriculture teachers highlighted as examples did not have great understandings of literacy content; therefore, they were more hesitant to use literacy strategies we shared as opposed to the more hands-on agriculture labs and activities presented in the PD. We believe this might be the case for a few reasons. First, when we examine the idea of "agricultural literacy," the definition itself is so heavily driven by agriculture content knowledge and thus does not address the literate practices needed to learn the agricultural content. While the teachers had multiple days to reflect on what agricultural literacy is, and how reading, writing, speaking, and listening all are components of agricultural literacy, there was still a disconnect between the agricultural content they planned to implement with their students and the literacy practices they could bring into their classrooms to help their students engage in more authentic agricultural learning.

The disconnect between content teachers implemented with their students and literacy practices they brought into their classrooms to support student learning is not unusual. Park and Osborne (2006a) found that secondary agricultural science teachers had their students reading for approximately 20 percent of their class time; however, when it came to strategy instruction, they were less knowledgeable about, and in turn subsequently less frequent, in implementing strategy instruction. This notion was reaffirmed by additional work by Park and Osborne (2006b). Park et al. (2010) found agriculture teachers considered literacy instruction to be "supplemental" (p. 104) and they did not spend a substantial portion of class time on it; in fact, observations of the teachers in the study showed little evidence of explicit teaching of literacy strategies.

Second, intentionality is also a key. Unlike most of the teachers in the study, Kevin found success in implementing literacy strategies into his classroom practice over the year. He had his students engaging in disciplinary practices utilizing the terminology of the discipline in various lessons across the school year. Thus, Kevin tried to bring in more of a literacy focus in the classroom. However, this was an intentional focus of Kevin's learning throughout the year of PD. He acknowledged early in the institute that he needed to work specifically on vocabulary development with his students and tried to incorporate ways to do that in his teaching. Ashley and Walker did not have this same level of intentionality. As a result, they focused more on implementing the agriculture activities presented in the PD in their classrooms and did not emphasize the literate practices required to engage fully in those activities with their students.

Implications and Conclusions

In Mississippi and other states, national and state standards and curriculums (e.g., AFRN Content Standards [The National Council for Agricultural Education [The Council], 2015a], Mississippi College-and-Career Readiness Standards in Literacy in Science/Technical Subjects [Mississippi Department of Education, 2016], Mississippi Agriculture and Natural Resources curriculum [Mississippi Research & Curriculum Unit, 2023]) require teachers to teach students discipline-specific practices, including those in agriculture. For example, the MCCRS-ELA & LSTS requires students to "follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text" (Mississippi Department of Education, 2016, p. 152). The MCCRS- ELA/LSTS standards are not supposed to be taught by the English teacher; these science and technical subjects grades 11-12 standards are supposed to be implemented by the science and CTE teachers at the school site as part of their instruction. Moreover, The Council (2015b) created a crosswalk connecting their national standards for the various agricultural programs to the Common Core State Standards in ELA/LSTS (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010), which the MCCRS-ELA & LSTS are based upon.

However, this can be challenging for teachers who have not been trained to teach the literate practices of the discipline (e.g., reading, writing, language/discourse). Thus, teachers need to be provided resources to teach their students these practices. The PD and its focus on introducing the teachers to new pedagogical approaches provided agriculture teachers with ways to meet these challenges head on. Agricultural literacy is integral to the sustainability of our nation's production and distribution of food resources. Thus, teachers must be prepared to support students' capacity to understand and employ literacy practices associated with these various agricultural sectors.

References

Adams, S., & Leininger, G. (2017). *But I'm not a reading teacher! Literacy strategies for career and technical education*. Sandy & Gwen Always Learning.

Anderson-Levitt, K. M. (2002). *Teaching cultures: Knowledge for teaching first grade in France and the United States*. Hampton Press.

Authors. (2023).

Avalos, B. (2011). Teacher professional development in teaching and teacher education over ten years. *Teaching & Teacher Education*, *27*(1), 10–20. 10.1016/j.tate.2010.08.007

Barton, D., & Hamilton, M. (2000). Literacy practices. In D. Barton, M. Hamilton, & R. Ivanic (Eds.), *Situated literacies: Reading and writing in context* (pp. 7-15). Routledge.

Bellah, K. A., Dyer, J. E., & Casey, G. R. (2004). Agricultural education= agricultural literacy. *Agricultural Education Magazine*, *77*, 23-24.

Bennett, S.M. & Hart, S. M. (2015). Addressing the 'shift': Preparing preservice secondary teachers for the Common Core. *Reading Horizons*, *53*(4). Available at: http://scholarworks.wmich.edu/reading_horizons/vol53/iss4/5

Boix Mansilla, V., Miller, W. C., & Gardner, H. (2000). On disciplinary lenses and interdisciplinary work. *Interdisciplinary curriculum: Challenges to implementation*, 17-38.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher*, *33*(8), 3–15.10.3102/0013189X033008003

Brandon, H. (2012, March 30). *At what cost the discussion between agriculture and the public?*

Buczynski, S., & Hansen, C. B. (2010). Impact of professional development on teacher practice: Uncovering connections. *Teaching & Teacher Education*, *26*(3), 599–607. 10.1016/j.tate.2009.09.006

Chapman, D.L., & Lindner, J.R. (2018). *Teacher perceptions of the Georgia middle school agricultural education curriculum*. Proceedings of the Southern Region Conference, American Association of Agricultural Education (pp. 95-109). Jacksonville, Florida.

Choi, M. (2023). "Were not all chemists in here—we're just trying to get to the next level": Examining out-of-school literacies, identity, and disciplinary literacy. *Journal of College Reading and Learning, 53*(4), 257–279. httsp://doi.org/10.1080/10790195.2023.2221317

Coburn, C. E., & Stein, M. K. (2010). *Research and practice in education: Building alliances, bridging the divide*. Rowman & Littlefield Publishers.

Cosby, A., Manning, J., Power, D., & Harreveld,d B. (2022). A systematic review of agricultural literacy of school students. *Education Sciences*, *12*(235). https://doi.org/10.3390/edusci12040235

Cochran-Smith, M., & Lytle, S. L. (1993). *Inside/outside: Teacher research and knowledge*. Teachers College Press.

Creswell, J.W. (2007). *Qualitative inquiry research design: Choosing among five approaches* (2nd ed.). Sage.

Dale, C., Robinson, J.S., & Edwards, M.C. (2017). An assessment of the agricultural literacy of incoming freshmen at a land-grant university. *NACTA Journal*, *61(*1), 7-13.

Dyer, J.E., & Breja, L.M. (2003). Problems in recruiting students into agricultural education programs: A delphi study of agriculture teacher perceptions. *Journal of Agricultural Education*, *44*(2). 75-85. 10.5032/jae.2003.02075

Elliot, J. (1999). Food and agricultural awareness of Arizona public school teachers. *Proceedings from the 18th Annual Western Region Agricultural Education Research Conference*, Corpus Christi, TX, 207-216.

Flint, A., Zisook, T., & Fisher, T. E. (2011). Not a one-shot deal: Generative professional development among experienced teachers. *Teaching and Teacher Education*, *27*(8), 1163–1169. 10.1016/j.tate.2011.05.009

Friedland, E., Kuttesch, E., McMillen, S., & Hill, P.D.P. (2017). Listening to the voices of teacher candidates to design content area literacy courses. J*ournal of Inquiry & Action in Education*, *8*(2), 34-53. https://eric.ed.gov/?id=EJ1140137

Garet, M. S., Porter, A. C., Desimone, L., Birman, B., & Yoon, K. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, *38*(4), 915–945. 10.3102/00028312038004915

Gee, J. (1996). *Social linguistics and literacies: Ideology in discourses* (2nd Edition). Taylor and Francis.

Guskey, T. R. (2002). Professional development and teacher change. *Teachers and Teaching: Theory and Practice*, *8*(3/4), 381–391.10.1080/135406002100000512

Howden, S. M., Soussana, J. F., Tubiello, F. N., Chhetri, N., Dunlop, M., & Meinke, H. (2007). Adapting agriculture to climate change. *Proceedings of the national academy of sciences*, *104*(50), 19691-19696.

Hutcheson, A. (2020). *Measuring the effectiveness of the Mississippi Agriculture in the Classroom Program on elementary students' agricultural literacy levels (Publication No.* 27838291) [Masters thesis. Mississippi State University.] ProQuest Dissertations & Theses Global.

Ivanitskaya, L., Clark, D., Montgomery, G., & Primeau, R. (2002). Interdisciplinary learning: Process and outcomes. *Innovative higher education*, *27*(2), 95-111.

Keiny, S. (1994). Teachers' professional development as a process of conceptual change. In I. Calgren, G. Handal, & S.Vaage (Eds.), *Teachers' minds and actions: Research on teachers thinking and practice* (pp. 232–346). Routledge Farmer.

Kohnen, A. M., & Whitacre, M. P. (2017). What makes professional development coherent? Uncovering teacher perspectives on a science literacy project. *Action in Teacher Education, 39*(4), 414-431. 10.1080/01626620.2017.1336130

Kovar, K. A., & Ball, A. L. (2013). Two decades of agricultural literacy research: A synthesis of the literature. *Journal of Agricultural Education, 54*(1), 167-178. 10.5032/jae.2013.01167

Krathwohl, D.R. (2002). A revision of Bloom's taxonomy: An overview. *Theory Into Practice*, *41*(4), 212-218.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.

Lemley, S.M., Alley, K.M., & Clary, R.M. (2023). *Building the architecture to incorporate 'literacy' in agricultural literacy*. Literacy Research Association Annual Conference, Atlanta, GA.

Lemley, S.M., & Hart, S.M. (2019). Using inquiry to develop agricultural education preservice teachers disciplinary literacy pedagogy. *Journal of Agricultural Education, 60*(4)*,* 149-163. doi: 10.5032/jae.2019.04149

Lemley, S.M., & Hart, S.M. (2018). Using inquiry to develop art and music preservice teachers' disciplinary literacy pedagogy. *UBIQUITY: The Journal of Literature, Literacy, and the Arts, 5*(1), 49-73.

Lemley, S.M., Hart, S.M., & King, J.R. (2019). Teacher inquiry develops elementary teachers' disciplinary literacy. *Literacy Research and Instruction, 58*(1), 12-30. doi: 10.1080/19388071.2018.1520371

Lewis, M. L. (2018). *Agricultural literacy among the generations: A national study* (Publication No. 10751140 [Doctoral dissertation, Tennessee State University]. ProQuest Dissertations & Theses Global.

Lieberman, A., & Wood, D. (2003). *Inside the national writing project: Connecting network learning and classroom teaching*. Teachers College Press.

McLaughlin, M. W., & Talbert, J. E. (1993). *Contexts that matter for teaching and learning strategic opportunities for meeting the nation's educational goals*. Stanford, CA: Stanford University, Center for Research on the Context of Secondary School Teaching.

Meischen, D. L., & Trexler, C. J. (2003). Rural elementary students' understandings of science and agricultural education benchmarks related to meat and livestock. *Journal of Agricultural Education*, *44*(1), 43-55.

Miller, A., Warnick, B., & Spielmaker, D. (2022). A case study: Agricultural literacy proficiency in an Iowa elementary school. *Journal of Agricultural Education*, *63*(4), 220-231. https:///doi.org/10.5032/jae.2022.04220

Mississippi Department of Education. (2016). *Mississippi college-and-career readiness standards*. https://www.mdek12.org/OAE/college-and-career-readiness-standards Mississippi State University Research & Curriculum Unit. (2023). *Curriculum.* https://www.rcu.msstate.edu/curriculum

Moje, E.B. (2007). Developing socially just subject-matter instruction: A review of the literature on disciplinary literacy teaching. *Review of Research in Education*, *31*, 1-44. 10.3102/0091732X07300046

Moje, E.B. (2008). Foregrounding the disciplines in secondary literacy teaching and learning: A call for change. *Journal of Adolescent & Adult Literacy*, *52*(2), 96-107.

Moje, E.B. (2015). Doing and teaching disciplinary literacy with adolescent learners: A social and cultural enterprise. *Harvard Educational Review*, *85*(2), 254-278.

National Council for Agricultural Education. (2015a). *National AFNR content standards*. https://thecouncil.ffa.org/afnr/

National Council for Agricultural Education. (2015b). *AFNR career cluster content standards crosswalk.* https://ffa.app.box.com/s/n6jfkamfof0spttqjvhddzolyevpo3qn/file/294149331493

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common core state standards for English/language arts and literacy*. Author.

National Research Council. (1988). *Understanding agriculture: New directions for education*. National Academies Press.

Park, T.D., & Osborne, E. (2006a). Content area reading strategies and textbook use in agricultural education. *Journal of Agricultural Education*, *47*(4), 1-14.

Park, T.D., & Osborne, E. (2006b). Agriscience teachers' attitudes toward implementation of content are reading strategies. *Journal of Agricultural Education*, *47*(4), 39-51.

Park, T.D., van der Mandele, E.S., & Welch, D. (2010). Creating a culture that fosters disciplinary literacy in agricultural science. *Journal of Agricultural Education*, *51*(3), 100-113. 10.5032/jae.2010.03100

Pense, S.L., Beebe, J.D., Leising, J.G., Wakefield, D.B., & Steffen, R.W. (2006). The agricultural literacy of urban/suburban and rural twelfth grade students in five Illinois high schools: An ex post facto study. *Journal of Southern Agricultural Education Research*, *56*(1), 5-17.

Penuel, W. R., Sun, M. I. N., Frank, K. A., & Gallagher, H. A. (2012). Using social network analysis to study how collegial interactions can augment teacher learning from external professional development. *American Journal of Education*, *119*(1), 103–136. 10.1086/667756

Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher*, *29*(1), 4–15. 10.3102/0013189X029001004

Rainey, E.C., Maher, B.L., Coupland, MD., Franchi, R., & Moje, E.B. (2018). But what does it look like? Illustrations of disciplinary literacy teaching in two content areas. *Journal of Adolescent & Adult Literacy*, *61*(4), 371-379. 10.1002/jaal.669

Ranganathan, J., Waite, R., Searchinger, T., & Hanson, C. (2018, December 5). *How to sustainably feed 10 billion people by 2050, in 21 charts.* https://www.wri.org/insights/how-sustainably-feed-10-billion-people-2050-21-charts

Ray, D.K., West, P.C., Clark, M., Gerber, J.S., Prishchepov, A.V., & Chatterjee, S. (2019). Climate change has likely already affected global food production. *PLoS ONE*, *14*(5), https://doi.org/10.1371/joural.pone.0217148

Saldaña, J. (2021). *The coding manual for qualitative researchers* (4th Ed.). SAGE.

Shanahan, T., & Shanahan, C. (2008). Teaching disciplinary literacy to adolescents: Rethinking content-area literacy. *Harvard Educational Review*, *78*(1), 40-59.

Specht, A.R., McKim, B. R., & Rutherford, T. (2014). "A little learning is dangerous: The influence of agricultural literacy and experience on young people's perceptions of agricultural image. *Journal of Applied Communications*, *98*(3), 63-73. https://doi.org/10.4148/1051-0834.1086

Stahl, N.A., & King, J.R. (2020). Expanding approaches for research: Understanding and using trustworthiness in qualitative research. *Journal of Developmental Education*, *44*(1), 26-28.

Stammen, K. M. (2019, August 9). *Sharing facts about modern agriculture is crucial*. https://ofbf.org/2019/08/09/publicizing-facts-agriculture-crucial/

Strike, K., & Posner, G. (1992). Revisionist theory of conceptual change. In R. A. Duschl & R. J. Hamilton (Eds.), *Philosophy of science, cognitive psychology, and educational theory and practice* (pp. 148–176). State University of New York Press.

Texas Farm Bureau. (2024). *Ag in the community*. https://texasfarmbureau.org/youth/ag-in-the-community/

Trexler, C.J., & Hikawa, H. (2001). Elementary and middle school agriculture curriculum development: An account of teacher struggle at countryside charter school. J*ournal of Agricultural Education*, *42*(3), 53-63. 10.5032/jae.2001.03053

Van Driel, J. H., & Barry, A. (2012). Teacher professional development focusing on pedagogical content knowledge. *Educational Researcher*, *41*(1), 26–28. 10.3102/0013189X11431010

Vescio, V., & Adams, A. (2015). Learning in a professional learning community: The challenge evolves. In D. Scott & E. Hargreaves (Eds.), *The Sage handbook of learning* (pp. 274–284). SAGE.

Webb, N. L. (2002, March). *Depth of knowledge levels for four content areas*. Unpublished manuscript. Wisconsin Center for Education Research, University of Wisconsin-Madison, Madison, WI. Retrieved from http://facstaff.wcer.wisc.edu/normw/All%20content%20areas%20%20DOK%20levels%2032802.doc

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge University Press.

Windschitl, M. (2019). Disciplinary literacy versus doing school. *Journal of Adolescent & Adult Literacy*, *63*(1), 7-13. http://dx.doi.org/10.1002/jaal.964

Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). SAGE.