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Teachers' Perceptions and Practices of Inquiry-Based Teaching and Learning Using CASE Curriculum

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Abstract

Curriculum for Agricultural Science Education (CASE) was first offered in 2007 with two foundational courses built on inquiry-based learning. Ten courses are now offered, each requiring intensive training and teacher development for effective use. Guided by National Science Education standards and a constructivist learning theory framework, the study used online survey research methods to explore teachers' perceptions of and practices associated with inquiry-based teaching and learning when using CASE curriculum. A survey link was distributed in September 2018 to teachers certified in an introductory CASE course (Agriculture, Food, and Natural Resources) and a higher-level, more inquiry-based CASE course (Food Science and Safety) for comparison. The online questionnaire was completed by 392 participants for a usable response rate of 32%. Major findings in the study included (1) participants in both groups have an understanding of open inquiry but struggled in identifying structured and guided inquiry; (2) participants over-estimated the amount of open inquiry in the curriculum; and (3) participants showed mixed interpretations of inquiry-based and problem-based instruction among both groups. Participant ratings of the CASE curriculum were generally favorable, although results showed that teachers frequently remove or skip lessons and teach courses in a semester or quarter format, contrary to CASE recommendations. Findings are discussed in the context of improved training and other recommendations to help teachers use the curriculum in its intended manner and to get the most benefit from its use.

Keywords: curriculum for agricultural science education; inquiry-based learning; teacher perceptions; teacher practices; problem-based instruction

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Introduction

Twenty-first century agriculture involves innovations in science, technology, engineering, and mathematic (STEM) fields. Given the integration of basic and applied aspects of traditional STEM disciplines in modern agriculture (NRC, 2009), it is vital that agricultural education keeps pace with innovation and new information. One of the research priority areas identified in the American Association for Agricultural Education (AAAE) National Research Agenda (Doerfert, 2011; Stripling & Ricketts, 2016) focuses on effective integrated STEM education in school-based agricultural education pedagogy.

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As a result, agricultural educators are exploring innovative teaching strategies to increase student achievement in both agriculture and STEM subjects (Wells et al., 2015). Inquiry-based learning is a key teaching strategy being used to enhance student interest in various STEM areas and help students gain deeper understanding of scientific concepts (Wells et al., 2015). Inquiry-based teaching is typically demonstrated through discovery learning, depending on the aspects of learning the student is allowed to control (Colburn, 2000, 2004). Through inquiry-based instruction, students gain problem-solving and critical thinking skills and are encouraged to learn inductively through real-world examples.

Curriculum for Agricultural Science Education (CASE)

Perceiving the need for more inquiry-based educational resources to help students learn STEM in Agriculture, Food, and Natural Resources (AFNR), the Council for Agricultural Education collaborated with agriculture teachers in several states to develop Curriculum for Agricultural Science Education (CASE), starting with two foundational courses in 2007. The two courses, Principles of Agricultural Science – Animal, and Principles of Agricultural Science – Plant, were developed using expert teachers throughout the writing and developmental process to create an inquiry-based, industry-driven curriculum package. CASE has since expanded its offerings to ten curricula. In addition to its two original courses, CASE offers the following curricula: Introduction to Agriculture, Food and Natural Resources; Animal and Plant Biotechnology; Food Science and Safety; Agricultural Power and Technology; Mechanical Systems in Agriculture; Natural Resources and Ecology; Environmental Science Issues; and Agricultural Research and Development. Each curriculum represents a career development area defined by National Agricultural Education standards (Curriculum for Agricultural Science Education, 2010b). Each "pathway" (curriculum) starts with a foundation (e.g., animal science or plant science), and moves into specialization and then capstone of research. Curricula also align with national AFNR standards, as well as National Science Education Standards (NSES), Next Generation Science Standards, Common Core Mathematics, and Common Core English Standards.

The CASE model is described as "a careful blend of time-tested instructional strategies used to guide students in their studies to meet the demands of post-secondary education and careers in the Agriculture, Food and Natural Resource (AFNR) industries" (CASE, 2010, p.1). Specifically, CASE writers utilized Understanding by Design (Wiggins & McTighe, 2005) as a guide for designing lessons. Understanding by Design (UbD), often referred to as *backward design*, situates desired outcomes as the first step in planning a lesson, emphasizing the desired results first, rather than the activity or other aspects of a lesson. Each CASE curriculum is intended for implementation over an entire school year. Lessons within a unit are designed to be taught in a 45-minute period.

Further, CASE lessons were developed using a spiral approach in which key concepts are introduced and periodically reinforced with more complex subject matter throughout the curriculum (Curriculum for Agricultural Science Education, 2010c). For this reason, it is recommended that lessons be taught in their entirety and in the specified order. Significant modifications are discouraged as the loss of content could affect scaffolding of material. CASE recommends only minor customizing of content, such as replacing parts of lessons that refer to certain cities or states appropriate to a region or area. Teachers learn to use the curriculum through an intensive 10-day training in which they complete hands-on activities and submit assignments in preparation for offering them to their own students. Trainings are typically held in locations where there is adequate space and lab facilities for teachers to work though the lessons. The locations are often referred to as "CASE states" as not every curriculum is taught in the same state. A number of states teach more popular curricula while advanced curricula are typically taught in only one location (Table 1). Table 1 lists training for in-service teachers (institutions holding training for pre-service teachers are not included). Training emphasizes working through each lesson to ensure that in-service teachers can replicate it in their own classrooms. Little or no time is devoted to learning about the curriculum, how it was formulated, or the methods and theories that are embedded.

Table 1

CASE Courses, In-Person and Virtual for In-Service Teachers as of Feb. 2022 (CASE, 2021)

Course Taught	State(s)
Introduction to AFNR	MT, LA, TN, NJ, WY, NC MN, ID, IA
Principles of Agricultural Science – Animal	CO, IL, KY, CT
Principles of Agricultural Science – Plant	AZ, IL, NE, PA, MD
Agricultural Power and Technology	AK, TX
Natural Resources and Ecology	AK, NV
Animal and Plant Biotechnology	WV
Food Safety and Science	NM, NC
Environmental Science Issues	MD

Previous research has addressed CASE teachers' science teaching efficacy (Ulmer et al., 2013) and high school students' perceptions of the yearlong curriculum (Velez et al., 2012). More recently, Pauley et al. (2019) examined CASE and non-CASE certified teachers' interdisciplinary teaching intentions. However, limited research has focused on the effectiveness of CASE curricula with regard to CASE-trained teachers' knowledge of inquiry-based learning and their actual use of the curricula (Bird & Rice, 2021).

Purpose/Objectives

The current study seeks to describe teachers' understanding of inquiry-based learning and teaching. The study also explores teachers' perceptions of the CASE curriculum and their practices in implementing the curriculum post-training. Three research questions are posed to address study objectives:

1. What are CASE-trained teachers' understanding and experiences as related to inquiry-based teaching and learning?
2. What are CASE-trained teachers' perceptions of using the CASE curriculum with respect to inquiry-based instruction?
3. How do CASE-trained teachers use the CASE curriculum to practice (implement) inquiry-based instruction?

Literature Review

Agriculture education has the potential to expand K-12 STEM, especially science education. Professional societies, such as the National Research Council Board on Agriculture, advocated using agriculture, food and environmental systems to enhance teaching of inquiry-based science in K-12 settings (NRC, 1998). As the K-12 education system increasingly accepts agriscience courses for full or partial science credit, it is important that agricultural education direct scholarly attention to STEM content learning and application through inquiry-based instruction (NRC, 1998; Wells et al., 2005).

Teaching Approach in Science and Agricultural Education

While science education and agricultural education have developed as separate disciplines, Dewey's (1910) classic book *How We Think* introduced key concepts underpinning both fields. As a prominent philosopher in both agricultural and science education, Dewey's reflective *thinking* represents a chain of scientific reasoning, the scientific method, or the learning process (Newcomb et al., 2004; Parr & Edwards, 2004). Reflective thinking is commonly used in agricultural education and is recognized as a way of thinking to drive scientific inquiry in science education (NRC, 1996, 2000). Other scholars, such as Piaget, Brummer, and Vygotsky, also acknowledge the similarities of the pedagogical approaches, such as reflective thinking, that are used in both agricultural and science education (Parr & Edwards, 2004). Although agricultural and science education share similar attributes, science education has focused on inquiry-based teaching (NRC 1996, 2000) while agricultural education has stressed problem-solving approaches (Parr & Edwards, 2004) in the past two decades. Nonetheless, inquiry-based, and problem-solving instruction have much in common (Crunkilton & Krebs, 1982, Newcomb et al., 2004; Phipps & Osborne, 1988). Both highlight student-centered teaching strategies based in experiential learning (Knobloch, 2003). Table 2 shows comparable features between inquiry-based and problem-solving processes.

Table 2

Comparison of Problem-Solving Learning Process and Essential Features of Inquiry

Learning Process (Problem-Solving)	Essential Features of Inquiry
LP1: Experiencing a provocative situation	EF1: Involved in science-oriented question
LP2: Defining the problem	EF2: Priority to evidence with respect to a problem: observe, describe, record, graph
LP3: Seeking data and information	EF3: Use evidence to develop an explanation, establish relationship based on evidence
LP4: Formulating possible solutions	EF4: Connects explanation to scientific evidence.
LP5: Testing proposed solutions	EF5: Communicates and justifies
LP6: Evaluating the results	

Note. Sources: *Methods for Teaching Agriculture* (Newcomb et al., 2004) and *Essential Features of Inquiry* (NRC, 1996, 2000).

Although similar language may be used to describe problem-based and inquiry-based learning (Table 2), the two types of learning are driven from different philosophical perspectives. For example, in science education, inquiry-based instruction aims to help students explore and understand the natural world and propose explanations based on evidence. Problem-based instruction attempts to facilitate a learning environment that helps students solve problems in a manmade world and with the intent of creating a solution around constraints and limitations (NRC, 2014).

Theoretical Framework

The theoretical framework for this study is based on constructivist learning theory (Paget, 1973; Vygotsky, 1978). Constructivism highlights how learners construct knowledge by developing personal meaning out of experiences rather than passively receiving information (Matthews, 2002). Constructivism is the core of inquiry-based teaching and learning because inquiry-based instruction emphasizes students conceptualizing and developing their own meaning through active participation in learning processes (Brand & Moore, 2010; NRC, 2000). As CASE curricula were developed to address the need for more inquiry- and science-based learning in agricultural education, constructivism is a theoretical foundation of CASE curricula.

CASE adapts Colburn's (2004) conception of inquiry teaching, which has three distinct levels: structured inquiry, guided inquiry, and open inquiry. The levels are derived from who makes decisions about various aspects of laboratory activities: teacher or student (Colburn, 2004). In the first level, structured inquiry, students are provided with the question to be investigated and procedures but allowed to decide what data is to be collected. This experience could vary for students conducting the experiment, yet all students follow the same procedures. In the next level, guided inquiry, students build upon collecting and analyzing data, but are also creating procedures about a common question. With this method, students' experiments may vary, but the process will lead to classroom discussions about the experience, tying learning together. In the third level, open inquiry, students oversee nearly all decisions. Students develop the question and determine the procedures and data to be collected that revolve around a broad topic rather than a specific question. To differentiate levels of inquiry-based teaching, CASE aligns activities with structured inquiry, projects with guided inquiry, and problem-based lessons with open inquiry (CASE, 2012). In this study, we used the *Essential components of inquiry-based instruction* (Figure 1) (NRC, 1996, 2000) to analyze different levels of inquiry-based instruction both for CASE curricula and teachers' perspectives and practices. The *Essential components of inquiry-based instruction* is developed based on a constructivist framework (NRC, 1996), and is consistent with the three levels of inquiry-based instruction (Colburn, 2004). The *Essential features of classroom inquiry* rubric (Figure 1) identifies five components of inquiry-based learning and their variations, depending on the level of control accorded to teachers or students. It is commonly used in science education and agricultural education as a way to identify features of inquiry-based lessons.

Figure 1

Essential Features of Classroom Inquiry and their Variations (NRC 1996, 2000)

FIGURE 1

Essential features of classroom inquiry and their variations.

Essential feature	Variations			
1. Learner engages in scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Learner sharpens or clarifies question provided by teacher, materials, or other source	Learner engages in questions provided by teacher or other source
2. Learner gives evidence priority in responding to questions	Learner determines what constitutes evidence and collects it	Learner directed to collect certain data	Learner given data and asked to analyze	Learner given data and told how to analyze
3. Learner formulates explanations from evidence	Learner formulates explanation after summarizing evidence	Learner guided in formulating explanations from evidence	Learner given possible ways to use evidence to formulate explanation	Learner provided with evidence
4. Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner directed toward areas and sources of scientific knowledge	Learner given possible connections	
5. Learner communicates and justifies explanations	Learner forms reasonable and logical argument to communicate explanations	Learner coached in development of communication	Learner provided broad guidelines to use sharpened communication	Learner given steps and procedures for communication

More ———————— Amount of learner self-direction ———————— Less
Less ——————— Amount of direction from teacher or material ——————— More

Methodology

Participants

Online survey methods (Dillman, 2011) were used to address the three study questions. The population for the study was CASE-certified teachers who had completed training for either of two courses: Agriculture, Food & Natural Resources (AFNR), or Food Science & Safety (FSS). The sampling frame for the population was provided by CASE under a confidentiality agreement that specified all data regarding participants be password protected and remain confidential. The list included names, email addresses, and school information for all teachers who had completed a CASE training. The researchers focused only on those currently teaching, which resulted in a final list of 1,332 active teachers — 1,187 who had completed the AFNR course and 145 who had completed the FSS course.

AFNR and FSS were selected for comparison purposes across several items on the instrument as AFNR is an introductory, or "Level 1," course for CASE, and FSS is an advanced, or "Level 3," course. (Level 3 has fewer structured inquiry activities than level 1). As CASE-certified teachers have likely taken the AFNR course or had other experience with "Level 1" or "Level 2" courses before taking FSS, we suspected that the FSS participant group would have a greater understanding than the AFNR group of inquiry-based nuances embedded into the curriculum. This premise was further based on the assumption that FSS participants would have greater familiarity than AFNR participants with specific terms and the curriculum structure.

Instrument Design

Instrumentation was developed specifically for this research and implemented using the online survey tool Qualtrics. Two different instruments were created for the study: one for AFNR teachers and one for FSS teachers. The two instruments contained items unique to each curriculum but shared a common set of questions. Each instrument consisted of 42 questions across three sections. Each section pertained to a different research question.

Section 1. The instrument's first section corresponded with RQ1: "What are CASE-trained teachers' understanding and experiences as related to inquiry-based teaching and learning?" The section had nine items, including a set of matching-type questions in which participants were asked to identify different types of inquiry when presented with a definition. Participants were also given an open-ended question: "In your own words, please describe what 'inquiry-based learning' means to you." A text box was provided for participants to clarify their response or share additional context.

Additional questions in this section asked participants how often they used inquiry teaching in their classroom in a typical week and the type of inquiry most often used. Finally, a question asked participants what subject matter they were in control of most often when conducting inquiry-based lessons, and what subject matter their students were in control of.

Section 2. The second section corresponded with RQ2: "What are CASE-trained teachers' perceptions of using the CASE curriculum with respect to inquiry-based instruction?" This section featured ten questions about the CASE curriculum. Teachers were asked to identify and rate three lessons from the curriculum using the *Essential features of classroom inquiry* rubric (Figure 1). Specifically, teachers were asked to identify a lesson they felt was the most successful at demonstrating inquiry-based learning, a lesson that was unsuccessful at demonstrating inquiry-based learning, and their favorite lesson. A drop-down menu provided unit and lesson numbers, as well as a text box for participants to explain their response. To assist in rating the lesson, an interactive version of the rubric would appear and allow participants to select each item on the rubric they felt was relevant for the lesson. This research reports three types of inquiry — structured, guided, and open inquiry — for consistency with Colburn's (2004) framework.

To provide a basis for evaluating teachers' assessments, two members of the research team used the rubric to code all the lessons from the AFNR and FSS curricula. One of the coders is a trained science education expert and both coders have completed CASE training. Using the rubric, the coders assigned each lesson a numerical score from 6 to 20 points based on the amount and type of inquiry present. Scores for the highest level of inquiry, open inquiry, ranged from 16 to 20 points, scores for guided inquiry ranged from 11 to 15 points, and scores for structured inquiry ranged from 6 to 10 points.

To ensure inter-coder reliability, each coder assessed a group of lessons and then met to compare and discuss any differences in ratings. After two rounds of testing in this manner, the percentage of lessons coded the same by the two coders was approximately 97%. The coders then assessed the remaining lessons. Coder scores are provided in the findings as a basis for comparison with teacher scores.

Section 3. The third and final section of the instrument pertained to RQ3: "How do CASE-trained teachers use the CASE curriculum to practice (implement) inquiry-based instruction?" This section collected information about participants' curriculum practices as well as demographic characteristics. Curriculum practices addressed how teachers used the curriculum day-to-day, including number of weeks the CASE curriculum was taught, length of the period/block in which a class was taught, and length and number of class periods. These items provided insights on the structure of participants' classes and time periods available for implementing the curriculum. An additional set of questions gathered information on how teachers used the curriculum, including whether they ever skipped, removed, or replaced lessons. Participants were also asked the unit from which lessons were most frequently skipped or removed, the number of lessons skipped or removed, and why. Finally, participants were asked to rate their overall satisfaction with the curriculum and provided space for additional feedback.

Demographic items included questions on age, number of years CASE certified, years teaching agricultural education, and region of the country in which participants taught.

Field Test. The researchers field-tested the instrument to identify vague or otherwise problematic phrasing and ordering of questions before data collection. For the field test, the researchers enlisted a panel of eight experts, all of whom were CASE master or lead teachers. Four of the experts were lead instructors for AFNR, and four were lead instructors for FSS. The experts were asked to provide feedback on time needed to complete the instrument, clarity, and validity of questions. The majority of feedback addressed the length of time needed to complete the instrument as well as suggestions to alert participants to access the curriculum when answering certain questions. To address these suggestions, the researchers added lesson titles as well as corresponding unit and lesson numbers (i.e., 3.1.1) to enhance clarity of possible responses. Clarification was also added to the cover page suggesting that participants have access to the curriculum when completing some of the items.

Data Collection and Analysis

An email message and accompanying link granting access to the online questionnaire were distributed to 1,332 teacher email addresses in September 2018. The message explained the purpose of the study, assured participant confidentiality, and invited participation within four weeks. Once participants clicked on the link, they could complete and submit the electronic questionnaire. Following the initial mailing, 96 email addresses were found to be undeliverable and were removed in October 2018.

A follow-up email and survey link were sent to non-respondents two weeks following the original email. A third and final message and survey link were sent to non-respondents four weeks following the original mailing. A total of 392 online questionnaires were completed from 1,236 prospective participants for a usable response rate of 32 percent.

Descriptive statistics reported in this paper include frequencies, percentages and means. Data were analyzed using IBM SPSS Statistics, Version 26. Questionnaires that were only partially completed were inspected to assess the amount of missing data. Fully completed questionnaire sections were included in the analysis, while incomplete sections were not included. For example, if a participant fully completed sections one and two, but did not complete section 3, responses were used only for sections one and two.

Results

This section reports descriptive results from 392 participants – 349 teachers who completed the CASE AFNR course, and 43 teachers who completed the CASE FSS course. As participants had the option to respond or not respond to any of the questions, the number of valid responses varies among items. In addition, 37% of the respondents did not complete the questionnaire in its entirety, resulting in an increased number of missing cases for some items. The following sections provide information on study participants' basic characteristics, followed by results for each of the three research questions.

Participant Characteristics

Basic descriptive information collected from study participants included sex, age, years teaching agricultural education (or other subjects), and years participants have been CASE-certified.

Table 3

Participant Characteristics

			AFNR (n=127[1])	**FSS** (n=19[1])
Sex	Male	*f* (%)	41 (32%)	5 (26.3%)
	Female		85 (67%)	12 (63.2%)
	Not Reported		1 (1%)	2 (10.5%)
Age	21-25	*f* (%)	15 (11.81%)	1 (5.26%)
	26-30		34 (26.77%)	5 (26.32%)
	31-35		15 (11.81%)	6 (31.58%)
	36-40		26 (20.47%)	3 (15.79%)
	41-45		9 (7.09%)	4 (21.05%)
	46-50		11 (8.66%)	--
	51-55		8 (6.30%)	--
	56-60		5 (3.94%)	--
	61-65		3 (2.36%)	--
	66-70		1 (0.79%)	--
Years teaching		Mean (SD)	10.65 (7.5)	11.26 (5.7)
		Range	1-26	4-23
Years CASE Certified		Mean (SD)	4.1 (2.4)	5.42 (2.4)
		Range	1-9	1-9

Note. [1]Missing data: A total of 222 AFNR teachers and 24 FSS teachers did not complete this section of the instrument. Descriptive statistics are reported for respondents only.

Data provided in Table 3 reveal that about two-thirds of the respondents were female with a modal age of 26-30. Years teaching ranged from 1 to 26. AFNR teachers reported an average of more than 10 years teaching, while FSS teachers averaged more than 11 years teaching. Number of years CASE certified ranged from 1 to 9 years across both groups. AFNR teachers reported being CASE certified for an average of about 4 years, while FSS teachers reported holding CASE certification for an average of more than 5 years.

Teachers were also asked to disclose the region of the country in which they teach. Results revealed that participants tend to be concentrated in the upper Midwest, with smaller, yet dense, concentrations on the East and West coasts.

Teachers were asked their reasons for becoming CASE-certified. More than half of the AFNR and FSS participants (51.3% AFNR; 59.3% FSS) indicated it was a personal desire. More than one-fourth of both groups (26.7% AFNR; 29.6% FSS) cited professional development as the key reason. Relatively few (less than 10%) of the participants indicated seeking CASE certification as a requirement of their school.

Regarding the number of CASE classes taught, more than three-fourths (77.2%) of AFNR teachers reported teaching between one and three classes, while just under half (47.4%) of FSS teachers reported teaching between one and three classes. No AFNR teacher taught more than six CASE courses; one FSS teacher reported teaching more than six courses.

Research Question 1

Section 1 of the instrument focused on inquiry and inquiry-based learning and teaching. Participants were asked to describe "inquiry-based learning" in their own words. Common responses included: "students research a solution to a question," "students solving problems to discover the content information," "learning through doing, exploring," and "hands-on learning." A majority of responses incorporated ideas related to hands-on learning, student-led activities, and investigations to discover something. Following this question, participants were asked to identify elements most often incorporated into their lessons. Both AFNR (*n*=200) and FSS (*n*=30) teachers cited hands-on learning most frequently. Examples shared included dissections, experiments, and development of models or projects.

Participants were also asked to categorize eight items based on how important each was for students to gain from an inquiry-based lesson. The eight items were *student understands a concept*; *student is able to perform a task*; *student is able to ask a meaningful question*; *student is able to make a research plan, including data collection and analysis*; *student is able to interpret data*; *student is able to communicate the data*; *student is able to think outside the box and have more inquiry regarding the topic*; and *student gains interest in exploratory learning*. The three ranking categories were labeled *most important*; *somewhat important*; and *less important*. The majority of AFNR (78.9%) and FSS (89.7%) teachers selected the response "the student understands a concept" as the most important item. The second most important response selected was "students are able to think outside the box and have more inquiry regarding the topic" (64.0% AFNR; 73.3% FSS).

Participants were then asked to identify the different levels of inquiry when given the definition. Teachers from both groups could easily identify open inquiry (76.5% AFNR; 82.1% FSS) but struggled with identifying guided inquiry (41.4% AFNR; 60.7% FSS). An open-ended question that related to different levels of inquiry was also offered to participants to expand upon their response. Common responses ranged from "I did not know there were multiple levels;" "I have never heard of this;" and "I knew what open [inquiry] was, but for others I guessed."

Next, teachers were asked about their practices using inquiry-based learning, including how often inquiry teaching was used in their classrooms. Both AFNR and FSS teachers cited using inquiry teaching an average of three days per week. AFNR teachers cited using structured (45.6%) and guided (45.4%) inquiry most often. FSS teachers cited using structured inquiry most often (56.7%), followed by guided inquiry (33.3%).

Participants were also asked what learning aspects were mostly controlled by their students during an inquiry-based lesson. The six choices were *topic*; *selecting the question or problem to research*; *designing the project, research, experiment, etc.*; *collecting the data*; *concluding results, lab reports*; and *other*. The most frequent response was collecting the data, followed by concluding results, lab reports.

Research Question 2

This section of the instrument addressed Research Question 2: "What are CASE trained teachers' perceptions of using the CASE curriculum with respect to inquiry-based instruction?" Participants were asked questions about the curriculum relating to inquiry-based learning and the essential features of classroom inquiry and their variations (Figure 1, NRC 1996, 2000).

The first series of questions asked participants to select a lesson they considered successful in demonstrating inquiry-based learning. Among 94 AFNR lessons, participants selected 36 lessons as best representing inquiry-based learning. The most frequent (*n*=18) selection was a lesson titled 'Mad Science,' in which students conduct an experiment involving water with assigned equipment (e.g., pH sensors, temperature sensors, balances.) Participants assigned the lesson a mean score of 18.7, whereas the coder score was 13 (Table 4).

The AFNR lesson participants scored the closest to the researchers' code was titled 'Drink This,' a project where students test water quality with various sensors. The participants (*n*=10) assigned the lesson a mean score of 19, which was consistent with the coder score (16) indicating open inquiry. Overall, participants rated 7 lessons as being the highest level of inquiry (open inquiry) while the researchers coded only one lesson, 'Drink This,' as being open inquiry throughout the AFNR curriculum (Table 4).

Table 4

Participant and Expert Ratings of CASE Lessons, AFNR (n=122[1]) and FSS (n=19[1])

Lesson rated most successful in demonstrating inquiry-based learning			
		AFNR Participants	
Lesson	f^2	**Mean (SD)**	**Expert Rating**
3.2.4 Mad Science	18	18.7 (1.55)	13
4.3.5 Drink This	10	19.0 (0.82)	16
5.3.5 Optimal Growth Ranges	10	18.9 (0.99)	12
		FSS Participants	
Lesson	f^2	**Mean (SD)**	**Expert Rating**
7.1.1 Innovative Inquiry	7	18.7 (0.95)	14
7.1.2 Filling Food Gaps	5	19.4 (0.89)	17
2.1.6 Ingredient Swap	3	19.0 (1.73)	11
Lesson rated as not successful in demonstrating inquiry-based learning			
		AFNR Participants	
Lesson	f^2	**Mean (SD)**	**Expert Rating**
1.1.2 Agriscience Notebook	22	6.0 (1.54)	4
1.1.3 Popp'n with Orville	11	6.9 (1.52)	6
1.2.4 Joining the Team	7	7.9 (2.10)	6
		FSS Participants	
Lesson	f^2	**Mean (SD)**	**Expert Rating**
1.1.2 Food Science Notebooks	5	5.2 (1.10)	4
1.1.3 History of Food Science	3	6.8 (2.20)	4
4.2.5 Non-Thermal Exploration	5	11.0 (0.00)	9
Favorite Lesson			
		AFNR Participants	
Lesson	f^2	**Mean (SD)**	**Expert Rating**
3.1.4 Measure Me	12	14.3 (3.10)	9
1.2.5 Game Time	8	14.2 (3.65)	8
4.4.1 Separating the Pieces	8	13.1 (3.20)	12
		FSS Participants	
Lesson	f^2	**Mean (SD)**	**Expert Rating**
4.1.1 Processing Commodities	4	14.5 (0.58)	9

Table 4

Participant and Expert Ratings of CASE Lessons, AFNR (n=122[1]) and FSS (n=19[1]), continued…

7.1.3 Introducing Innovation	4	20.0 (0.00)	15
4.1.4 Poultry Processing	3	14.7 (2.30)	12

Note. [1]Missing data: A total of 227 AFNR teachers and 24 FSS teachers did not complete this section of the instrument. Descriptive statistics are reported for respondents only.
[2] Frequency of participant rating.
[3] Rating scale: 16 to 20, open inquiry; 11-15, guided inquiry; 6-10, structured inquiry.

FSS lesson participants were also asked to select a lesson they considered successful in demonstrating inquiry-based learning. Among 57 total lessons in the FSS curriculum, seven were selected as best at representing inquiry-based learning. The most frequent (*n*=5) selection was a lesson titled 'Innovative Inquiry,' in which students begin the planning process for creating a new food product. Participants' mean score for the lesson was 18.7, indicating open inquiry. The research team scored the lesson as 14, indicating guided inquiry. Participant and researcher codes were closest for the lesson 'Filling Food Gaps'; the researchers coded the lesson as a 17, and the participants scored it as a 19.4. In this instance, the participants and researchers scored the lesson as open inquiry.

Next, participants were asked to select a lesson they felt lacked inquiry. The lesson selected most frequently by 30 AFNR teachers was 'Agriscience Notebook.' This lesson requires students to follow a list of directions to prepare their agriscience notebooks for the year. Teachers felt this lesson mainly involved students following a set of directions that could have been assigned as homework, rather than as an individual lesson. The lesson overall was rated by teachers as being very low inquiry with a score of 6.

Two FSS lessons were most frequently rated as lacking inquiry: 'Food Science Notebooks' and 'History of Food Science.' The first lesson requires students to follow directions to prepare their lab books, while the second lesson addressed food history events such as pasteurization and required students to develop a timeline. Both lessons were selected by five teachers and had mean scores of 5.2 and 6.8, respectively. Sample comments from FSS and AFNR teachers indicated the tasks were "monotonous" and "had little student influence."

Participants were also asked to select a favorite lesson. The AFNR lesson selected most often (*n*=14) was 'Measure Me.' The lesson, from Unit 3, involves students exploring different measurement tools such as thermometers, graduated cylinders and scales. Participants gave the lesson a mean score of 14.3, indicating guided inquiry. Sample comments included: "There is a lot of hands-on and questions about the substance, following directions [is] very important."; "I really like this lesson because the students are starting to understand why we do scientific processes. They have a lot of fun with it as well because usually they figure out it is Jell-O towards the end of the experiment"; and "It's really hands-on but doesn't require an insane amount of prep, it's also one of the students' favorites, probably because they get a little competitive."

The most favored (*n*=5) FSS lesson was 'Processing Commodities.' This is the first lesson in Unit 4 in which students engage in basic food processing techniques by making butter, strawberry jam, and bread. Participants rated this lesson with a mean score of 14.5, indicating guided inquiry. Sample comments included: "4.1.1 has the kids make food that is tasty, accessible, and that they want to make again! It is usable information."; "Students begin to connect the lab with items they use (and take for granted) each day"; and "The students enjoy the lesson, and I enjoy showing them the science behind canning and the preservation of fresh fruits."

Research Question 3

The third and final section of the instrument addressed Research Question 3: "How do CASE-trained teachers use the CASE curriculum to practice (implement) inquiry-based instruction?"

The researchers wanted to explore the number and duration of class periods available to implement the curriculum. Table 5 outlines teachers' course timeframes and length of class periods. Results showed that nearly two-thirds (63.5%) of AFNR teachers and nearly three-fourths (73.9%) of FSS teachers implement the CASE curriculum in a typical one-year (36+ week) timeframe. In terms of class period lengths, AFNR teachers most frequently reported 46-60 minutes as their typical class length, while FSS teachers reported 30-45 minutes most frequently. More than one-fourth of both AFNR and FSS teachers reported a class period exceeding 60 minutes.

Table 5

Teachers' Implementation of CASE Curriculum by Course Length and Class Period Length

	Time Frame	AFNR (n=125[1])	FSS (n=19[1)])
Time frame of course	One-year (36+ weeks)	63.5%	73.9%
	Semester (12-18 weeks)	22.2%	21.0%
	Quarter/Trimester (9-11 Weeks)	3.9%	--
	Other	10.3%	5.3%
Typical class length	30-45 Minutes	25.6%	46.4%
	46-60 Minutes	45.6%	21.1%
	61+ Minutes	28.8%	29.6%

Note. [1]Missing data: A total of 224 AFNR teachers and 24 FSS teachers did not complete this section of the instrument. Descriptive statistics are reported for respondents only.

The researchers also queried participants in how they select course lessons. Over half (52.8%) of AFNR teachers and nearly one-third (31.6%) of FSS teachers reported including or passing over lessons on an individual basis rather than teaching all lessons as a unit. Nearly one-third (29.6%) of AFNR teachers and half (52.6%) of FSS teachers reported following the lessons in the recommended order. Nearly all teachers (95.2%) reported skipping, removing, or replacing at least one lesson. More than two-thirds (70.4%) of AFNR teachers reported skipping four or more lessons, while the major of FSS teachers reported skipping one to three lessons (Table 6).

Table 6

Skipped, Removed or Replaced Lessons

	Number of lessons	AFNR (n=125[1])	FSS (n=19[1])
Number of lessons skipped	0	5.6%	0%
	1-3	24.0%	63.2%
	4-6	31.2%	15.8%
	7-9	14.4%	5.3%
	10+	24.8%	15.8%

Table 6

Skipped, Removed or Replaced Lessons, continued…

	Unit Number		
Unit from which the most lessons have been skipped or removed	Unit 7	26.3%	6.2%
	Unit 3	6.8%	31.2%

Note. [1]Missing data: A total of 224 AFNR teachers and 24 FSS teachers did not complete this section of the instrument. Descriptive statistics are reported for respondents only.

AFNR teachers reported skipping lessons from Unit 7 (26.3%), a terminal unit in the curriculum, most frequently. Lessons from Unit 3 were the most frequently (31.2%) skipped among FSS teachers.

The most common reason given for removing or skipping CASE lessons was lack of supplies, followed by running out of class days, not liking the lesson, and perceiving the lesson as too easy. Less frequently, teachers cited removing lessons because of inadequate class time or a perception that the lesson was too challenging for the class. When asked why they were replacing or modifying lessons for their needs, a majority of teachers cited that they had materials for the lesson they replaced. These teachers reported often preferring their lesson to the one they replaced and sometimes replacing only part of a CASE lesson.

Finally, participants were asked to rate the degree to which the CASE curriculum fit their expectations of teaching agricultural education through inquiry-based learning. Ratings were measured on a percentage scale (1%-100%), and participants had the option to explain their rating with a textbox. Both AFNR teachers (n=118) and FSS teachers (n=19) rated the curriculum fairly high (AFNR: M=81.26, SD=17.35; FSS: M=87.47, SD=12.67). Sample positive characteristics attributed to the CASE curriculum by AFNR participants included: "… the perfect balance of background information, structured learning, and open inquiry;" "… all the hands-on and how it is truly science-based inquiry;" and "I enjoy CASE tremendously. I do not think I would still be teaching if I was not CASE certified."

Open-ended responses also included elements of dissatisfaction with the curriculum. Sample responses from AFNR participants include: "not nearly enough inquiry-based labs, they are all WAY too guided"; "too much information, not enough time to get through all of the information"; "It's a good framework, but I do not think all lessons are the same level of quality"; and "cost of materials is quite hard to cover." Other responses included concerns about inconsistencies in the curriculum, excessive dependence on worksheets, and lack of agricultural applications. Only one FSS participant provided an open-ended response to this question (regarding the prohibitive cost for schools).

Conclusions and Implications

Results from this descriptive study contribute to the literature by providing insights into how teachers use the CASE curriculum in their classrooms. A key finding is teachers' overall perceived high quality of the curriculum and its potential to unify and improve the teaching of science in agricultural education programs nationally. The conclusions and recommendations that follow are made in the spirit of assisting CASE in building upon these strengths and expanding its national impact.

Our findings show a disparity between teachers' perceptions of using inquiry-based instruction and their actual classroom practices. Teachers perceived the purpose of inquiry-based instruction is to engage students in a problem-solving process that includes helping students gain control of their experiments, think outside the box, and investigate and discover solutions to problems. However, in their daily practices of inquiry-based instruction, students were given control of data collection and analysis only in teacher-structured or guided experiments. Additionally, helping students think outside the box was not listed as teachers' top priority of their daily practices of inquiry-based teaching. It is important to note that teachers were self-aware that they used structured or guided inquiry most often in their classrooms. Their self-reported daily practices indicate only a rudimentary understanding of different levels of inquiry-based instruction. More than half the teachers indicated they had difficulty identifying nuances separating guided from structured inquiry.

In particular, teachers were unable to differentiate among the various levels of inquiry that are built into the CASE curricula. Teachers consistently tended to rate CASE lessons at higher levels of inquiry than the researchers rated them. Teachers often rated CASE lessons they used daily as open inquiry, contrary to researchers' ratings. It should be noted that CASE lessons are structured using the activity, problem, and project-based model, which means students engage mostly in structured inquiry daily and rarely cross into open inquiry (Curriculum for Agricultural Science Education, 2010a). Teachers' lack of understanding may lead them to the mistaken conclusion they have achieved the highest level of inquiry-based instruction. The discrepancy between teachers' understanding of the level of inquiry-based instruction in CASE curricula and classroom practices could thus affect students' development of inquiry skills and limit their problem-solving abilities (Keselman, 2003; Pedaste et al., 2012).

Our findings demonstrate that teachers recognize student-centered instruction and hands-on activities as essential features of inquiry-based teaching. They acknowledged the common language (e.g., student-centered, and hands-on activities) and scientific practices (e.g., data collection and analysis) that were used in inquiry- and problem-based instructions (Knobloch, 2003). However, teachers' indiscriminate use of the terms "inquiry-based" and "problem-based" indicate they have only a limited understanding of philosophical differences between these two types of instruction. Inquiry-based instruction helps students learn about the scientific process, which allows them to investigate how and why natural phenomena occur (NRC, 1996, 2000). In contrast, problem-based instruction aims to help students develop creative solutions to solve problems and make informed decisions in their lives (NRC, 2014). Although inquiry- and problem-based instruction share similar language and scientific processes, the end goals are distinctive.

Problem-based instruction is commonly used in agricultural education and is well known to agricultural teachers (Parr & Edwards, 2004). CASE curricula adapts both the APPB model, which is a system that challenges learners to develop skills to solve complex problems, and Colburn's levels of inquiry-based learning. In other words, CASE curricula have incorporated both inquiry- and problem-based instruction. Therefore, it is important to elaborate the philosophical differences between inquiry- and problem-based learning and provide a clear teaching goal to teachers to avoid confusion.

Possible modifications in CASE training may help teachers better understand and differentiate among the three levels of inquiry and philosophical aspects of inquiry-based teaching. One option includes dedicating a training component specifically to the pedagogical development of CASE curricula, e.g., how the curriculum was developed and its underlying philosophy. Such a unit could expand to provide suggestions on how to transition students from structured inquiry to guided and open inquiry, or possibly encourage the addition of more open inquiry into the lessons. For example, results showed the most popular lesson among teachers involved structured inquiry with many hands-on activities, regardless of curriculum (AFNR or FSS). If teachers are able to recognize the different levels of inquiry, they could adjust their favorite lesson from structured inquiry to guided and open inquiry. Armed with knowledge to identify the levels of inquiry, teachers may be able to optimize the curriculum and thus address their perceptions that particular lessons were too easy or difficult. As CASE encourages personalization of the curriculum, such modifications could be explained to teachers as a type of customization open to them.

Since 2020, CASE training has required participants to complete CASE foundations focusing on the CASE design process, assessment, instructional practices, inquiry-based practices, and curriculum navigation (Bird & Rice, 2021). However, the impact of including CASE foundations in terms of level of inquiry-based instruction (e.g., the differences in CASE activities, projects, and problem-based lessons), and the philosophical difference between inquiry- and problem-based instruction remains unknown. To address this challenge, scholarly and professional societies such as AAAE or the Council for Agricultural Education could assist in helping teachers understand inquiry-based instruction, including its demonstration and possible applications in agricultural education, through workshops at national meetings, professional development sessions, online trainings or in partnership with local universities.

Another key finding from this research is that teachers often deviate from CASE recommendations when implementing the curriculum in their classrooms. CASE recommends the curriculum be taught over an entire school year in 45-minute periods. Our findings revealed that teachers often choose not to teach some lessons consecutively in a given school year. Some indicated moving content or splitting it across courses, possibly reducing effectiveness of the curriculum's "spiral" design. Additionally, teachers indicated picking and choosing individual lessons or adding lessons to accommodate substitute teachers. Still others indicated removing lessons because students were unable to obtain needed results. One interesting finding was that teachers most frequently skipped AFNR lessons from Unit 7. As CASE units progress, so does the level of inquiry. Therefore, Unit 7 presumably offers the highest level of inquiry, yet was most frequently skipped by teachers. It is possible that key concepts and practices of higher-level inquiry-based learning could be lost from the curriculum in these circumstances.

Results showed that time was a factor contributing to teachers' skipping and removal of lessons. Most teachers reporting having class periods ranging from 30 to 60 minutes. Because CASE lessons are typically designed for 45 minutes, having additional time does not pose an issue. However, having less than 45 minutes threatens the quality of instruction. To address this situation, CASE should consider modifying their curriculum offerings to accommodate block schedules and semester courses. The development of stand-alone and "a la carte" lessons might also offer more flexibility to accommodate unavoidable time constraints. Modifications could involve offering a suggested schedule, along with lessons from the current curriculum that could be taught over a quarter or semester. Equipping teachers with best practices in implementing and, when necessary, modifying the curriculum based on their needs would help ensure the curriculum is used consistently and in its entirety. The curricular options and trainings suggested here could potentially reduce the amount of student knowledge currently being lost due to skipping and modifying lessons.

In addition to time constraints, teachers' most frequently cited reason for skipping and removing lessons was lack of needed materials. Bird and Rice (2021) found similar results in their research. CASE lessons require the use of specific equipment, LabQuest 2®, which is manufactured by Vernier. In addition to LabQuest 2®, teachers need multiple sensors in each lesson. LabQuest 2® devices and sensors are costly, and all teachers may not have access to such equipment. Modifying lessons to match available lab equipment might necessitate teachers rewriting lessons, which undermines the value of a coordinated and comprehensive curriculum (Curriculum for Agricultural Science Education, 2010c). Given this difficulty, CASE might consider offering increased flexibility for needed materials. Specifically, options might exist for CASE to modify curricula or suggest alternative materials for schools that cannot afford to equip their classrooms with specialized equipment. Such an adjustment would more effectively support teachers and schools with limited resources. The provision of supplemental materials would demonstrate that high-quality inquiry-based curriculum is accessible to all teachers and schools.

This study examined only descriptive factors of select CASE teachers. Future research should include more detailed observations on how teachers use the curriculum to assist CASE in continuous quality improvement. Case study methodology could be beneficial in providing insights into how the curriculum is implemented at the classroom level. Survey research would also be valuable in examining teachers' understanding and use of problem-based and inquiry-based lessons. There is a need to better understand the current confusion that exists among teachers about the two teaching philosophies. Research comparing the foundational understanding of teachers who completed training before CASE foundations were implemented and those who completed CASE foundations could help inform future training content. Survey research would also offer opportunities for statistical modeling of teacher preferences and behaviors.

Limitations

Several factors limit the external validity of this study. First, the study includes only a sample of teachers using CASE curriculum. Second, the research addresses only two (AFNR and FSS) of 10 possible curriculum groups, which limits generalization beyond the current study participants and curricula. Further, this research does not take into consideration curricular changes made after 2020, including the addition of CASE foundations. Finally, the study is limited by missing data as many respondents did not complete the online questionnaire in its entirety. As a result, much of the demographic information describing respondents was not captured.

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