

Immersive Experiences in Agriculture for STEM Teachers

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Abstract

The implementation of ChLOE at Ohio State University provided science teachers with authentic agricultural experiences for integrating agriculture in their classes through a professional development session and field trip with their students. The purpose of this explanatory mixed-methods study is to evaluate the ChLOE's impact on teacher participants' knowledge, beliefs, and application of the program content. The quantitative questionnaire indicated that the program was beneficial for students and teachers through the reported implementation of the pedagogies taught during the professional development and immersive experiences during the field trip. The qualitative follow-up interviews indicated that teachers perceived high student engagement during the field trip and a plethora of intended and reported behavior change through the integration of professional development and field trip within the classroom. The expansion on the quantitative results by the qualitative suggests that the behavior changes are congruent with the additional beliefs and knowledge acquired by the teachers throughout the ChLOE program. OSU should align educator programs, including ChLOE, with evolving teacher needs and evaluate student outcomes to ensure relevance to instructional goals. Overall, teacher professional development programs should cater to a variety of teacher needs and curriculum.

Article History



Received: October 7, 2025

Accepted: June 14, 2026

Published: June 30, 2026

Keywords

field trips; pedagogy; professional development; program evaluation; SDG 4: Quality Education

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Introduction and Problem Statement

Limited skills, prospects, and training hinder youth from seeking agriculture and natural resources-related careers (Dhakal et al., 2018; Nankervis et al., 2017). To encourage understanding of agriculture and career opportunities, agriculture should be integrated into school settings. Only 11,000 agricultural and agriscience teachers teach middle and high school students in the United States (National Association of Agricultural Educators, 2024). However, every kindergarten to 12th grade student in the United States takes science classes, resulting in over one million science teachers covering a range of subjects such as physics, biology, and chemistry (Zippia, 2021). Agricultural teachers can't serve every student. Integrating agriculture into science classes can increase access to agriculture.

Agriculture has been entwined with science, including technology, engineering, and math (STEM) repeatedly. Integrating agricultural experiences and examples within STEM classrooms can promote interdisciplinary learning for students and teachers (McKim et al., 2018; Pauley et al., 2019; Wang et al., 2020). Interdisciplinary learning, integrating concepts from multiple content areas in one session or class, can increase students' positive attitudes, metacognition, engagement, confidence, and critical thinking while increasing teacher's skills, productivity, and creation of active learning communities (Hubert, 2021; Ivanitskaya et al., 2002; Pauley et al., 2019; Wang et al., 2020).

Professional development can provide science teachers opportunities to integrate agricultural content into their curriculum. The Children Learning through Outdoor Experiences (ChLOE) program at The Ohio State University (OSU) provides professional development for teachers and a subsequent field trip for them and their students to encourage the integration of agricultural content in STEM classes. Therefore, exploring the impact of ChLOE can help assess the efficacy and relevance of an agricultural interdisciplinary program for science teachers.

Theoretical and Conceptual Framework

The conceptual framework of this study was the Core Features of Professional Development (Desimone, 2009). Desimone suggests that when teachers engage in effective professional development, they enhance their knowledge and skills or change their attitudes and beliefs, leading them to improve their instruction which in turn increases student learning. Effective teacher professional development according to Desimone (2009) includes five features: content focus, active learning, coherence, duration, and collective participation. Content focus refers to the activities that center on the subject matter of the training, as well as the methods by which students may learn the content. Active learning emphasizes engaging teachers in hands-on learning, interactive feedback, and discussions, as well as teaching observations. Coherence includes consistency with teachers' current knowledge and relevance to institutional curriculum policies. Duration prioritizes sufficient span and length of time for professional development. Collective participation includes support and connection with other attendees as well as buy-in from school personnel (Desimone, 2009).

This framework has been commonly used throughout education research, including in online instruction, pedagogy, global competence, and STEM self-efficacy (Fernandes et al., 2023; Langelaan et al., 2024; Meyer et al., 2023; Schipper et al., 2020; Zhang et al., 2024; Zhou et al., 2023). Programs designed following the Core Features of Professional Development have had a statistically significant positive impact on teacher's self-efficacy and competency (Fernandes et al., 2023; Zhou et al., 2023). Many teacher education programs reflect the Core Features of Professional Development (Fernandes et al., 2023; Langelaan et al., 2024; Zhou et al., 2023).

OSU's program included professional development that sought to fulfill the critical requirements of effective training. The program used content focus through the inclusion of the professional development session on science pedagogy. Active learning was evident through the hands-on immersive experiences and through activities during the science pedagogy training session. The field trip was designed by the teachers and program staff based on the curriculum and needs of the teachers, providing coherence. The science pedagogy training and one day field trip aimed to provide the teachers with sufficient time to spark learning and interest and a chance to apply their science pedagogy learning after the professional development. Collective participation was attained through the co-development of the program with the teachers and the program administrators and teacher interaction during the science pedagogy session. The entire ChLOE reflected the features identified by Desimone (2009).

This research focused on how professional development impacted teachers' knowledge, skills, beliefs, attitudes, and their behavior change in the classroom post-professional development and future plans post-field trip. This framework was underscored in the development of the research through the inclusion of understanding the relevance of the program, its use in their classrooms, and knowledge changes following the teachers experience of the entire program. Numerous studies using this framework focuses on the quality of the professional development or short-term knowledge, skills, and belief changes (Fernandes et al., 2023; Langelaan et al., 2024; Zhang et al., 2024); however, this novel research aims to extend beyond the training and characterize long-term behavior change in the classroom.

Purpose

The purpose of the study is to evaluate OSU ChLOE's impact on teacher participants to inform the work of future agricultural literacy programs. The objectives for the evaluation research are: (a) Identify teacher perceptions of the pre-experience training and field trip, (b) Determine teachers' perceptions of their ChLOE immersive experience and field trip, (c) Explore teacher perceptions of the experience on their students' learning, and (d) Discover teachers' use of ChLOE knowledge and practices pre- and post-field trip.

Methods

This impact evaluation followed an explanatory sequential mixed-method design to assess teacher perceptions and knowledge following their participation in the ChLOE program. A census was conducted for the online questionnaire and teachers self-selected into semi-structured interviews. Teachers were invited to participate in the online questionnaire which was then used to build the interview guide for the semi-structured interviews (Creswell, 2021; Watkins & Gioia, 2015). For the 2023-2024 program, eight teachers completed the online survey ($n = 8$) and four of those teachers participated in the follow up interviews ($n = 4$). The online questionnaire was disseminated through Qualtrics after being designed by the research team. The interviews were audio and video recorded for transcription. The data from the questionnaire was analyzed using descriptive statistics (Creswell & Creswell, 2023; Fraenkel et al., 2019). The data from the interviews was analyzed via in-vivo inductive coding through the constant comparative method (Corbin & Strauss, 2014; Creswell & Creswell, 2023). The in-vivo codes were then categorized into themes. The teachers were given pseudonyms to maintain anonymity and increase readability.

ChLOE Description

ChLOE is a national program focused on providing engaging agriculture and the outdoor experiential learning opportunities for teachers and students. OSU's ChLOE program offers science teachers an opportunity to apply immersive agricultural experiences in their science classes. Teachers who participate attend a science pedagogy professional development training. After the professional development, the teachers work with ChLOE administrators to choose immersive experiences for their field trip on their chosen date that are most relevant to their students and curriculum. The teachers chose up to four immersive experiences per field trip from 17 fall semester options and 14 spring semester options. These immersive experiences were created based on the availability of experts related to the project. Teachers did have the option to co-design a niche immersive experience if they chose. For the field trip, the teacher collaborates with different OSU field experts to deliver each experience's content to their students at the Agricultural and Natural Resources Laboratory. The field trip includes lunch and the immersive experiences during one school day. Ohio Soybean Council funded the program and covered the cost of participating in the teacher professional development and field trip. At the data collection point, 20 teachers completed the science pedagogy training, but only 11 teachers completed the entire professional development program due to schedule and time restraints (i.e., science pedagogy training and field trip with immersive experiences). Only teachers that completed the full program were included in this analysis.

Limitations

A limitation of this study is the non-response and attrition rates. While the response rate to the survey was 72.7%, there is a risk that those who did not respond may have had different experiences or opinions about the ChLOE. The attrition rate from the beginning of the program was 45%. The professional development event occurred in March, which is the beginning of the

state testing schedule in Ohio, so that the timing may have contributed to the attrition rate post-professional development.

Additionally, since the professional development occurred in March 2024, there is the risk that the participant teachers may not remember everything about the training on which they are answering questions since the training occurred up to seven months ago depending on when they completed the ChLOE program. We also did not collect data on the teachers who did not complete the full ChLOE program, which could provide further information about why they decided only to complete the pedagogy training without the field trip component. Since this study examines a training program with a small sample, there is limited generalizability of the results. However, since the focus of this study is to explore the impacts of the ChLOE rather than generalize to a larger group, external validity was not prioritized.

Participant Demographics

Of the teachers who completed the entire program ($n = 11$) by spring 2024, they chose 10 of the total 17 immersive experiences. On the field trips, the teachers brought a total of 490 students. By the data collection point, 8 teachers had completed the online questionnaire and four opted-in to the interview. Most participants taught biology or physical science, but they typically taught more than one science course ($n = 7$). Other courses taught by the participants included chemistry, human anatomy and physiology, life sciences, physics, and advanced research in science. The participants engaged in a variety of immersive experiences. The most popular were flower differences, plant grafting, and water quality with three each ($n = 3$). The average number of years of teaching experience was 24.125 years, though half of the teachers had more than 30 years of experience. Of those that had agricultural experience ($n = 6$), their experience included 4-H participation, growing up on a farm, attending workshops and locations that include agriculture and natural resources, running a farm operation, and being the facilitator for the National Agriscience Teacher Ambassador program. Of the immersive experiences, the niche-designed experiences, those designed specifically for that teacher by the program team, were the most common ($n = 5$). Table 1 provides the personal characteristics of the participant teachers and their experiences.

Table 1*Personal Characteristics of Participants and their Experiences (n = 8)*

Variable	#	%
Previous Agricultural Experience		
Yes	6	75.0
No	2	25.0
Subjects Taught		
Biology	5	23.8
Physical Science	5	23.8
Environmental Science	4	19.1
Other	3	14.3
Chemistry	2	9.5
Life Sciences	2	9.5
Grades Taught		
12 th Grade	5	17.9
11 th Grade	5	17.9
10 th Grade	5	17.9
9 th Grade	5	17.9
8 th Grade	3	10.7
7 th Grade	3	10.7
6 th Grade	2	7.1
Experiences Attended		
Niche-Designed	5	20.8
Flower Differences	3	12.5
Plant Grafting	3	12.5
Water Quality	3	12.5
Animal Nutrition	2	8.3
Entomology	2	8.3
Soil Testing	2	8.3
Sticky, Spreadable, Edible Water	2	8.3
Tree ID	1	4.2
Yield Predictions	1	4.2

Findings

The summary of the quantitative findings is outlined in Table 2. The respondents *agreed* that the science pedagogy professional development was beneficial ($M = 4.10$, $SD = 1.02$). Some teachers reported incorporating pedagogy from the professional development into their teaching before the field trip. The pedagogical content and skills from the science pedagogy professional development were utilized by most teachers ($n = 7$). They also *agreed* that the planning process was effective ($M = 3.91$, $SD = 1.38$) and the field trip engaged the students ($M = 4.33$, $SD = 0.86$). The teachers *strongly agreed* that agriculture belonged in STEM curriculum

($M = 4.63$, $SD = 0.67$) and that they increased their knowledge of agriculture and natural resources on the field trip ($M = 4.58$, $SD = 0.50$).

Table 2

Descriptive Statistics of Teachers' Perceptions (n = 8)

Variable	<i>M</i>	<i>SD</i>
Agriculture in STEM	4.63	0.67
Knowledge Gain	4.58	0.50
Student Engagement	4.33	0.86
Beneficial Training	4.10	1.02
Effective Planning	3.91	1.38

All participants indicated their plans for integrating the ChLOE field trip into their classes. All the teachers planned to integrate the materials and experiences from their field trip and science pedagogy professional development into future topics such as fermentation, genetics, sustainability, and evolution. Some also discussed including more hands-on activities ($n = 5$) such as soil testing, water quality, and engineering challenges.

Interview Findings

The four interviews conducted highlighted the respondents' motivations for engaging in ChLOE, their experiences, and their future plans. Each of these sections is detailed further and are inductively summarized as it corresponds to questions asked during the interviews.

Motivations for Program Engagement

Overall, the motivations for participants to engage had on three themes: exposing students to new opportunities, engaging them, and enhancing their skills.

Regarding exposing students to new opportunities, Tanya said: "This could be a great experience in terms of careers for kids" and "I'm always trying to get kids to understand that farming is so much more than cows and plows, especially in a suburban setting." For engaging students, Susan said they participated because "it gets students outside." Jennifer detailed that the students "need to have hands-on activities". Susan said, "they understand why it's important to take a chemistry class." Erin said, "I'd much rather be doing something outside than inside. So, I'm always on the lookout for a really good opportunity to learn more about teaching science and learn more about how to engage students more in science, especially outdoor type stuff." In reference to increasing students' skills, Erin said, "They [students] don't really understand where the where the food actually comes from."

Personal Experiences

With respect to their experiences, teachers discussed both the field trip and the pedagogy training which emerged into four themes: student engagement, personal engagement, negative

experiences, and refresher course. For the field trip, many teachers focused on their students' engagement. Jennifer mentioned, "I enjoyed the fact that the students were engaged. They took away from this experience just some more knowledge maybe a little bit of curiosity on how science is used outside of the classroom." Susan commented, "I think the students had no idea that there were different kinds of plants in monocots and dicots, and so just the fact that she had picked dozens and dozens and dozens of flowers, and then they were able to sort through them and figure that all out was really helpful for them."

Other teachers focused on their own impression of the field trip. Jennifer said, "I love to see what other people are doing. In the field, in research." Susan said, "[the immersive experience was] helpful as far as application for our farm." Tanya said, "I felt like a big old kid." For the sessions that occurred in the fall, many of the teachers were able to take a tour of the new greenhouse on campus. This experience was a big hit amongst the teachers. Tanya said, "It was just me and my science mind going the greenhouse tour was off the charts, amazing. I wish we could have spent more time in there." Erin said, "[Tour guide] did a really good job telling us what the research was. I thought that was pretty valuable for the kids to see...these are scientists doing real world research."

One teacher shared a negative experience with the field trip. They discussed issues with logistics and the lack of opportunity for students to participate in the experiences the teacher had requested. Erin said, "I was...a little disappointed with the things that I chose to do and the things that we actually did were not the same." Also, they said, "I really wanted the edible water [immersive experience] ...I was super looking forward to that, and [professor] did not show up." Additionally, they shared, "I just felt like there was a lot of chaos going on." "There just wasn't that that [tomato seed planter] was really the only hands-on activity that I felt like, you know, was really good engaging the kids."

Regarding the professional development training, teachers discussed how the content was more of a refresher course with new concepts built in. Susan said, "it was a good reminder it for me." Likewise, Tanya noted, "I wouldn't say that was anything new to me, like it's, it's not, it didn't revolutionize my world." However, referencing new content in the training, Susan said, "I haven't really scaffolded my lessons that way before." Jennifer said, "it was good as far as like learning new pedagogy." Another common thread was how the participants enjoyed discussing the practice of teaching with other science teachers. Susan said, "that [working with other teachers] was an interesting piece of it," and "I enjoyed listening to other people's responses." Also, Erin shared, "I think it was the ability to discuss ways to teach science with my colleagues who teach the same thing. I thought that was invaluable."

The teachers' personal experiences were varied, but they mostly had a positive experience throughout the ChLOE. The teachers perceived their students as actively engaged during the immersive experiences. While some teachers mentioned issues with engagement and the level of programming not aligning with their students' abilities, the feedback was overwhelmingly positive. The majority of teachers felt that they and their students benefited from the experience. All teachers said that they would like to participate in the program again and would

recommend it to other colleagues. These results highlight the positives of the programming, despite some planning or implementation challenges.

Plans and Integration

The teachers' plans included using soil testing in their class, applying for a future grant to bring their students on a farm tour, an agricultural engineering problem-solving exercise, and building a school greenhouse. They also planned to refer to the field trip for examples during their classes. Most of the teachers integrated the ChLOE in multiple ways. For example, Susan said, "We started the digestive system right after [the field trip]. So, it was really easy to pull all of that [animal digestion] back in and talk about. Well, here's why this animal has a has...to ferment their food. So, let's do a fermentation lab to go along with it. It gave me lots of different ideas." She also was "... working on putting in a pollinator garden. So, at first the idea was just get some flowering plants before the OSU thing, that you would have in your yard that would attract bees. But now we're going the native species route and looking at getting native species for it and try to arrange them in a way that's more like a garden." Susan also reported, "We did some soil testing...What was the Ph of the soil? And is it gonna be okay to support this particular plant or not?" Jennifer said, "We're going to be starting a what's called Westland Gardens. And we're doing raised beds out in a fenced in area." Jennifer also said, "Two field trips next year, one to the OSU farm, and then also getting them out to the Metro Parks." Tanya reported, "I completely redesigned what I typically did [hydroponic bucket activity] ...so what they basically did is just calculate the biodiversity of their backyard." Erin said, "Once we do get into content, you know, using our experiences on the ChLOE field trip, that that will be integrated into our class discussions." These results indicate the variety of techniques the science teachers used and will use, based on the ChLOE, within their classrooms following the field trip.

ChLOE had a mostly positive response from teachers. These results highlight the critical use of science pedagogy professional development to help teachers prepare themselves and their students for the field trip. It also suggests that the training could provide benefits not directly related to the field trip since only just over half of the teachers who completed the training participated in the field trip.

Additionally, the ChLOE field trip may have provided further professional development for the teachers. Much of the plans in both the questionnaire and the interviews were congruent with the immersive experiences they participated in, rather than the professional development session. These immersive experiences played a large role within future plans for curriculum and extra-curricular projects. The immersive experiences specifically targeted future and current curriculum, as evidenced by the number of niche-designed experiences developed for the teachers based on their needs compared to the frequencies of the other available immersive experiences.

Data Integration

The qualitative results align with the quantitative results. Overall, the teachers perceived the science pedagogy training as beneficial and described using the taught pedagogical methods in their classrooms before the field trip and plan to use them after the field trip. Most participants used at least one technique from the training, which aligns with some interviewees' insinuation that the professional development taught them new scaffolding methods and increased their knowledge. This confirmation indicates a change in behavior among some participants. The reported behavior changes further support the efficacy of the professional development, which may increase student learning, aligning with Desimone's (2009) core features of professional development.

The future plans provided by the interviewees also indicate that topics related to agricultural and natural resources are readily applicable to STEM classes, regardless of the subject. Both the interviews and the questionnaire provided insights into their future plans. The interviews also demonstrated follow-through on the plans reported in the questionnaire, as they were conducted later, further suggesting behavior change. While some teachers did mention that professional development was "more of a refresher," they did enjoy learning from their peers and discussing science teaching practices with them, which coincides with the agreement level for the quantitative portion. In addition, the belief that agriculture belongs within STEM education was reinforced during interviews with participants. The combined results indicate that the behavior changes are congruent with the additional beliefs and knowledge acquired by the teachers throughout the ChLOE. However, our sample only includes science teachers who participated in the program suggesting that this belief may have developed prior to their participation in ChLOE.

Conclusions, Discussion, and Recommendations

Engaging science teachers and students in ChLOE at OSU can address teacher and students' lack of knowledge spanning agriculture and natural resources content. ChLOE could increase consumers' informed involvement in local, regional, and national food systems by filling knowledge gaps. Aligning with Desimone's (2009) Core Features of Professional Development, the professional development session on science pedagogy and subsequent field trip supports that behavior changes can occur when professional development incorporates the core features. Specifically, the field trip with immersive experiences was highlighted by the participants due to its large amount of active learning by both the teachers and their students. In addition, teachers, for whom the science pedagogy training helped them remember pedagogical skills and knowledge they had previously learned, used it in their classes post-training and was deemed as helpful by the teachers. Therefore, professional development that uses repeated exposure to skills and knowledge coupled with active learning may be most beneficial for teachers.

The program should assess student experiences and continue monitoring and evaluating teacher experiences to support the path from teacher behavior change to increased student

learning (Desimone, 2009). In the future, this program should consider adjusting the timing of the professional development to increase teacher completion. Following up with the teachers who did not complete the field trip would also provide valuable insight into the program and its professional development. In the future, working more closely with teachers to ensure that the programming available fits their curriculum would be ideal. Either offering more immersive experiences or suggesting immersive experiences based on the students' grade level could allow for more attuned programming, but also more engaging experiences for the students. Ensuring that communication between teachers and program facilitators is transparent, including who will be available to conduct the programming and their availability, and what those programs entail. By including the latter, teachers can be better prepared in instances where students will be separated into groups, as well as possibly front-loading them with information that could make the immersive experiences more engaging, memorable, and enjoyable. Programming that provides teachers and students with objects or kits to take home, including a suggested lesson plan or instructions, could also facilitate teachers' inclusion of these kits and objects in their classroom post-field trip.

The ChLOE program and similar programs should consider involving all subject matter teachers to foster additional interdisciplinary learning. Broadening this program to include more teachers, and therefore students, may enhance interest in agricultural professions aligning with Dabney et al. (2012). By expanding to include non-science teachers, immersive experiences could be adapted to reflect those teachers' programming needs more generally. For example, with flower or tree identification programs, emphasizing the etymology of plants' scientific names could be appropriate for language curricula. For yield prediction, students could compare indigenous methods and modern agricultural methods in terms of yields.

Overall, ChLOE has begun connecting teachers and students to agriculture and natural resources. Many of the teachers highly recommended the greenhouse tour. Incorporating this experience in future ChLOE field trips should be paramount. Deepening the connections students and teachers have to agriculture and natural resources is of the utmost importance. Increasing students' awareness of agricultural practices and professions could enhance their inclination to pursue careers that merge science and agriculture. By engaging teachers, ChLOE enables science teachers to act as advocates for agriculture.

Acknowledgments

Funding Information: No funding was provided for this research..

Conflict of interest: The authors report no conflict of interest.

Previous Dissemination: Part of this research was included in a conference paper. Zickafoose, A., & Claflin, K. (2024). *Integrating Agriculture into STEM Education through Immersive Experiences [Conference Paper]*. National Conference on Learner-Centered Teaching 2024, Tulsa, Oklahoma, USA.

Artificial Intelligence: No artificial intelligence was used during the research or in manuscript preparation.

Author Contribution Statement: **A. Zickafoose** – conceptualization, methodology, formal analysis, investigation, writing-original draft; **K. Claflin** – conceptualization, supervision, writing-review and editing.

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