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As Agricultural Education shifts to a more science-based curriculum to help fulfill shortcomings of the current United States science test scores, teachers implementing Inquiry-Based Learning (IBL) is becoming more important. For Agriculture Educators to do this, training is necessary for both new and experienced educators. This study was conducted to gauge teacher attitudes toward and ability to integrate IBL in the classroom to meet these goals. Teacher knowledge was also assessed in four life science categories. Study results indicate that teachers have positive attitudes toward learning about IBL and implementing the model in the classrooms. Teachers also gained more content knowledge in life science by completing the training. With proper training and experience in all levels of teachers, IBL methodology can be a useful tool in the agriculture education classroom.

Keywords: Inquiry-based learning (IBL), professional development, Agricultural Education, teacher knowledge, teacher attitudes

Introduction

Agricultural education has a history of incorporating hands-on instruction and integration of the sciences for students to understand and retain information regarding food and fiber production. However, as agriculture and agricultural education change, and expectations of student capabilities and understanding change, teaching methods must adapt (Wells et al., 2015). Inquiry-based learning (IBL) encourages students to seek solutions to a stated problem, which allows for a greater understanding of the issue (Parr & Edwards, 2004). IBL is an educational approach that fosters student curiosity through the use of the scientific method to develop a deeper understanding of scientific principles (Warner & Myers, 2011). Agricultural education programs are a prime educational area to incorporate IBL as an instructional method (Wells et al., 2015).

According to the National FFA Organization (2020), agricultural education courses offer students systematic instruction in science. Students who participate in agricultural education programs can build interest in a career pathway to achieve career success, personal growth, and leadership development with the goal of making informed decisions as they advance through life. Building interest in a career pathway is one reason IBL implementation complements agricultural education programs and curricula (National FFA Organization, 2020). The National FFA Organization has developed programming to assist agricultural education teachers with implementing IBL in their classrooms. One tool is the FFA Agriscience Fair, where students use the scientific method to solve problems (National FFA Organization, 2020).

For IBL instruction to be effective, teachers need adequate training to implement IBL into their classrooms productively (Thoron & Burleson, 2014). Therefore, this study was conducted to determine teachers' attitudes regarding implementing and using an IBL model in their classrooms and the perceived change of attitude after completing a year-long professional development. Researchers collected data on teacher attitudes, understanding, and implementation of the IBL model, along with gauging their knowledge and growth in subject-specific topics within the life science content area.

Literature Review

According to the National Science Foundation (2012), the United States falls short in science education compared to other nations. In a Pew Research Study, the United States ranked 38th in math and 24th in science out of 71 countries studied (Desilver, 2017). In addition, only 29% of Americans feel that K-12 science, technology, engineering, and mathematics (STEM) are above average compared to the world (Desilver, 2017). A 2013 article in the *New York Times* (Dreifus, 2013) shared interviews conducted with teachers, professors, students, and business leaders. These individuals provided their opinions on current science education systems and suggestions for change. Mitzi Montoya, the dean of Arizona State University College of Technology and Innovation, said education should provide increased opportunities for problem-solving. She also indicated that emphasis had been placed on content when the focus should be on context (Dreifus, 2013). Dianne Marie Omire-Mayor provided insight from a student perspective. In her interview, she said students desire more hands-on learning rather than memorizing textbooks (Dreifus, 2013).

Agricultural education looks to STEM research to help develop assumptions about sciences taught in agricultural classrooms. According to Weiman (2012), the goal for educators is to design educational experiences that allow learners to develop thinking processes similar to experts in a relevant field of study. As teachers work to develop experts, they simultaneously increase students' abilities to think critically and solve problems (Weiman, 2012). Thoron and Burleson (2014) surveyed 170 students. They found 44.2% of students agreed or strongly agreed that they would select learning through inquiry over other teaching methods, and 52.3% said they would enjoy participating in more courses that use an IBL model of instruction in their courses. IBL instruction requires curiosity from the learner and uses the scientific method to encourage critical thinking. (Warner & Myers, 2011). In a classroom setting, the use of IBL develops a deeper understanding of scientific principles (Warner & Myers, 2011) and assists in strengthening students' cognitive abilities through exposure to issues that require deep thought and understanding (Wells et al., 2015). Further, Thoron and Myers (2012) indicated that IBL places students first, and the teacher serves as a facilitator rather than a lecturer.

Agricultural education has long placed a major focus on science, mathematics, and other academic content (Wells et al., 2015). Specific legislation, theoretically implemented to enhance education, has influenced course content as schools attempt to meet various academic standards (Wells et al., 2015). With agriculture courses placing more focus on science-based curriculum, it is important that teachers use instructional methods that enhance student understanding. A collaborative relationship between students and teachers must develop for IBL to be effective (Shoulders & Myers, 2011). In Thoron and Burleson's (2014) study, IBL instruction was a positive experience for students and helped give students a positive outlook on agriculture. Students also showed interest in taking more courses with IBL instruction, suggesting that IBL is an effective tool for teaching science concepts in the agriscience classroom setting (Thoron & Burleson, 2014).

Traditional teaching methods, also known as subject matter-based learning (SMBL), are commonly used in classrooms. In a quasi-experiment, Thoron and Myers (2012) found IBL methods increased student argumentation skills compared to SMBL. Argumentation skills can be directly connected to a student's ability to think critically without being concerned about reaching a correct answer. Students possess a stronger ability to develop reasoning and conclusions based on scientific evidence and data (Thoron & Myers, 2012). Therefore, traditional SMBL classroom settings do not foster a learning environment conducive to developing conclusions based on evidence. Instead, IBL supports student needs as they enter careers in agriculture, attend college, or pursue other postsecondary education (Thoron & Myers, 2012). Implementing IBL can be difficult for teachers, according to Shoulders and Myers (2011). Various barriers include loss of classroom control, safety concerns, increased time requirements, student misconceptions, and subjective grading.

While teachers understand the importance of IBL strategies, the approach is commonly implemented using a teacher-led rather than a student-led approach (Washburn & Myers, 2010), signaling a need for more training. The National Agriscience Teacher Ambassador Academy (NATAA), which is part of the National Association of Agriculture Educators (NAAE), provides teachers with opportunities for professional development in IBL (NAAE, 2019). Through the academy's professional development opportunities, teachers learn how to enhance science-based curriculum using IBL methods, gain resources from companies and colleagues, and learn how to train students to become critical thinkers and problem solvers (NAAE, 2019).

The National Academy of Science (2009) indicated that students should complete five different tasks when learning through inquiry: question, investigate, form evidence-based assumptions and predictions, connect evidence to prior knowledge, and share findings. In contrast, teachers are responsible for starting the inquiry process; promoting student dialogue; transitioning between small groups and classroom discussion; intervening to clear misconceptions or developing student understanding of content material; modeling scientific procedures and attitudes; and using student experiences to create new content knowledge.

Purpose and Objectives

The purpose of this study was to determine Nebraska teachers' attitudes toward IBL and their ability to integrate IBL into their classrooms. The focus was placed on the integration of curriculum, specifically in genetics, muscle biology, microbiology, and nutrition. Ten teachers learned to implement IBL into their curriculum through a year-long professional development training. The objectives of this study were to:

1. Gain an understanding of teacher knowledge of the following topics: genetics, muscle biology, microbiology, and nutrition;
2. Build a basic knowledge of a teacher's perceptions of teacher and student interactions in a classroom;
3. Determine the frequency that IBL is used in each teacher's classroom;
4. Examine each teacher's attitude towards IBL and learning how to implement IBL in their classroom.

Method

This study was conducted using 27 life science teachers across Nebraska, including science and agriculture teachers. The participating teachers were surveyed at the beginning of the professional development (PD) and again after completing the year-long development experience. These surveys were used to determine the following aspects of implementing IBL in a teacher's classroom: teacher attitudes (TA), life science knowledge (genetics, muscle biology, microbiology, and nutrition), teacher inquiry scale (TIS), and teacher/student process (TSP). Each survey used a Likert-type scale to collect the teacher's responses for analysis. Approval to conduct this study was received by the institutional review board.

Teacher attitudes about IBL were evaluated using 13 questions related to learning about and implementation of IBL in the classroom. Questions focused on various aspects of the IBL PD: implementation of IBL into the classroom curriculum, student engagement, and knowledge of IBL. Each question was answered using a Likert scale of 1 (*strongly disagree*) to 5 (*strongly agree*). To understand teachers' perceived level of base content knowledge before and after the PD, another Likert-type scale was used to collect data related to a teacher's knowledge of life science content from 1 (*not knowledgeable*) to 4 (*very knowledgeable*). Next, the Teacher Student Process instrument was utilized to examine each participant's perception of the roles a teacher and student must take in the classroom. The 11 questions were based around ideas of IBL methods. Participants answered questions using 1 (*strongly disagree*), 3 (*neutral*), and 5 (*strongly agree*). The questions were presented in both a positive and negative manner. Lastly, the Teacher Inquiry Scale measured how often the participating teachers implemented IBL in the classroom. Participants were asked about seven different IBL methods that could potentially be used in the classroom. Participants selected answers from *never* to *five times a week*.

The initial sampling group participated in preservice workshops to learn about implementing IBL instruction into curriculum that relates to life science topics. After completing a two-day workshop, teachers were expected to create lesson plans incorporating IBL to deliver instruction. The lessons that each teacher developed were shared with other participants in the group. Teachers were from schools across the state; therefore, virtual meetings were conducted throughout the school year to provide teachers with an opportunity to share their experiences. The virtual meetings allowed teachers to share ideas and frustrations and ask questions that could help them better implement IBL in their classrooms. Upon the conclusion of the year, participants participated in a one-day follow-up professional development experience. During this time, teachers retook the four surveys to re-evaluate each participant's thoughts concerning IBL and its utilized content.

Although 27 teachers were in the initial sample, only 10 teachers completed the yearlong professional development program. Only the data from the 10 teachers who completed the full year-long PD were included in the results of this research. Non-completers of the course can be attributed to teachers moving to a different state, conflicting priorities, and time constraints that did not allow teachers to finish. The pre-PD responses of the teachers that did not complete the course were removed from the data. Only responses of those who completed the pre- and post-PD surveys were recorded and used for data analysis. The data were analyzed using a paired *t*-test model to determine the significance of the pre- and post-professional development instruments used to collect data based on teacher attitude (TA), teacher/student process (TSP), and teacher inquiry scale (TIS). Life Science knowledge skills were evaluated using a simple pre/post-survey comparison of answers. The data collected for this study were part of a larger data set.

Findings

The findings from this study include the results of the 10 participants' responses to the four pre- and post-surveys. The data have been divided into four sections to correspond with the four different surveys. Each section will include a table of data and a description of the findings.

Teacher Attitude

Based upon the mean score of the 10 surveys, participants were generally favorable to learning about IBL prior to PD workshops. They felt that there was a greater need to implement IBL into the curriculum they were teaching and that this form of instruction benefits a student's ability to learn. As expressed in Table 1, the mean for teacher attitudes on the Likert scale was 4.26, with a standard deviation of 0.22 prior to the beginning of the PD. These numbers indicate that participants were generally agreeable about implementing IBL methodology, learning about proper IBL strategy, and that student engagement increases with IBL.

Table 1. TA Paired Sample Statistics

	Mean	*N*	Std. Deviation	Std. Error Mean
Post Mean	4.14	10	0.26	0.08
Pre Mean	4.26	10	0.22	0.07

According to the data collected in the post-PD survey, participants responded very similarly to their initial surveys. The mean score represented after the PD was completed was 4.14 (Table 1). A mean difference of -0.12 (Table 2) showed a slight decline in some participant responses. With similar answers in pre- and post-PD surveys and a significant number above .05, this instrument does not provide significant data to the outcome.

Table 2. Summary of Paired Samples

	Mean Difference	SD	SE	*t*	*p*
Post-TA-Mean - Pre-TA-Mean	-0.12	0.37	0.12	-0.39	.318

Life Science Knowledge

As Table 3 indicates, most participants displayed positive growth in knowledge of the different content areas. The Likert score indicates a teacher's knowledge of the different content categories. The frequency indicates how many teachers selected that particular score within the Likert scale. The percent and valid percent are a representation of the frequency as a percentage.

In Table 3, it can be determined that there was positive growth across all areas. The areas of muscle biology and microbiology showed the greatest growth, with pre-PD scores of one individual feeling *not knowledgeable*, eight feeling *somewhat knowledgeable*, and one feeling *knowledgeable*, compared to post-PD scores of five feeling *somewhat knowledgeable* and five feeling *knowledgeable*. The participants felt more knowledgeable about genetics and nutrition than muscle biology and microbiology. However, participants still showed growth in their knowledge about genetics and nutrition.

Table 3. Life Knowledge Skills

	Test	Likert Score	Frequency	Percent	Valid Percent
Genetics	Pre	2	3	30	30
		3	7	70	70
	Post	2	2	20	20
		3	7	70	70
		4	1	10	10
Muscle Biology	Pre	1	1	10	10
		2	8	80	80
		3	1	10	10
	Post	2	5	50	50
		3	5	50	50
Microbiology	Pre	1	1	10	10
		2	8	80	80
		3	1	10	10
	Post	2	5	50	50
		3	5	50	50
Nutrition	Pre	2	5	50	50
		3	5	50	50
	Post	2	3	30	30
		3	7	70	70

Teacher/Student Process

Only nine participants completed the teacher/student process instrument in both pre- and post-PD surveys. The pre-PD mean was 4.47, with a standard deviation of 0.38 (Table 4). This number indicates that participants were more agreeable with the questions and answered with scores closer to five.

Table 4. TSP Paired Sample Statistics

	Mean	*N*	Std. Deviation	Std. Error Mean
Post Mean	4.26	9	0.29	0.10
Pre Mean	4.47	9	0.38	0.13

Participants' answers shifted after completing the PD. There was a mean difference of -0.21 (SD 0.23; Table 5), expressing a shift towards more of a neutral ideology. With a significant number of .029 (less than 0.5), the Teacher/Student Process instrument showed significance in the outcome of the PD experience for the participants.

Table 5. TSP Summary of Paired Samples

	Mean Difference	SD	SE	*t*	*p*
Post-TSP-Mean - Pre-SP-Mean	-0.21	0.23	0.08	-2.67	.029

Teacher Inquiry Scale

A pre-mean score of 3.21 (Table 6) indicates that teachers implemented some form of IBL in their classrooms one to two times per week.

Table 6. TIS Paired Sample Statistics

	Mean	*N*	Std. Deviation	Std. Error Mean
Post Mean	3.09	10	0.5	0.16
Pre Mean	3.21	10	0.67	0.21

After completing the PD workshop, there was a mean score of 3.09 (Table 6) and a mean difference of -0.13 (Table 7). The significant number provided in this paired sampling set is .59 (Table 7). With this number slightly above the target number of .50, this instrument proves less significant than others in the study.

Table 7. TIS Summary of Paired Samples

	Mean Difference	SD	SE	*t*	*d*
Post-TIS-Mean - Pre-TIS-Mean	-0.13	0.74	0.24	-0.55	.59

Conclusion

Supported by literature, it is evident from this study that IBL is effective and vital to a student's success in agricultural education and science and that proper teacher training is essential for implementing an IBL model (Wells et al., 2015). Throughout this year-long PD program, 10 teachers developed lessons in genetics, muscle biology, microbiology, and nutrition that utilized IBL methods, where students were asked to observe, collect, and analyze data from firsthand events and phenomena (Eick & Reed, 2002). Through hands-on activities, students become more engaged in the scientific process and thinking by processing complex problems (Wells et al., 2015). By strengthening a teacher's ability to deliver IBL lessons, students better grasp scientific concepts, increasing science scores (Wells et al., 2015).

As shown in the Teacher Attitude data, the teachers who participated in the workshop were generally receptive to learning how to implement IBL methods into the curriculum. Throughout their experience, they developed a more diverse ability to teach using IBL. As seen in the pre- and post-data on content knowledge relating to life sciences, the participants also gained a deeper knowledge of the content in which IBL methods were used. However, there was a slight decline in the Teacher/Student Process data when comparing the pre- and post-surveys. It can be hypothesized that teachers thought they were implementing IBL in their classroom, but after learning more about the model, they realized they had a misconception of what IBL was and how it should be conducted in a classroom or lab setting.

IBL can be difficult for new teachers as they develop lessons due to a lack of knowledge and experience (Eick & Reed, 2002). If IBL is effective in teaching students, it can be effective in training teachers, which is reflected in the growth of scores teachers reported on the content knowledge surveys. Throughout the year-long PD, teachers became more comfortable implementing IBL in the four life science content areas addressed. When utilizing IBL, the teacher's role moves from being the sole source of knowledge to being a facilitator of learning (Wells et al., 2015). The teachers who participated in the PD continued to express their interest in implementing IBL methods in their curriculum at the conclusion of the workshop. Teachers indicated that they increased the frequency of using some form of IBL and felt more comfortable implementing it in their classrooms. Other studies have shown that student perspectives of agriculture education can also improve when IBL is used; therefore, it is a positive outcome of this study that teachers are willing to continue to learn about and implement IBL in their classroom and lab settings (Thoron & Burleson, 2014).

Implementing IBL methods into the classroom can prove to be beneficial for students and teachers. Students develop a deeper understanding of the curriculum taught by becoming investigators and accessing prior knowledge and understanding (Eick & Reed, 2002). Students tend to learn better with more ownership in their education. Students who learn through IBL tend to have a higher content knowledge than those who learn through a subject matter approach (Wells et al., 2015). Activities used in IBL are more student-centered than teacher-centered and should be directed towards a student's interest, creating more engagement in their learning (Eick & Reed, 2002). As funding can be tied to students' test performances, it is vital that schools and teachers foster a deeper understanding of science concepts in students (Wells et al., 2015). This study shows that teachers are willing to implement the model in their classrooms. Because of the willingness of teachers and the positive perspective of science and agriculture that students can gain from an IBL model, it is important that administrators support their teachers as they adopt practices centered around IBL (Thoron & Burleson, 2014).

IBL has also been shown as a positive way to approach science, math, and agriculture education. If schools shift to more teachers conducting lessons through an IBL model, student educational experiences can improve (Wieman, 2012). Further, if teachers try to increase the difficulty level of lessons and allow students to take the lead on solving a problem, students will be more invested in their learning, potentially increasing their understanding of the topic and improving test scores (Wieman, 2012). A goal of Agriculture Education is to prepare students for real-world situations and careers, and IBL can directly strengthen a student's knowledge, giving them an advantage in their future endeavors (Wells et al., 2015).

There is a need for more research and dialogue for implementing IBL into agricultural curricula (Wells et al., 2015). In this study, the implementation focused primarily on four life science-based topics. However, IBL could be implemented in other areas of the agricultural education curriculum. It would be beneficial for research to be conducted on implementing IBL into all seven pathways in agricultural education to provide more evidence as to why all educators should be utilizing this method. In order to implement IBL in all areas of agricultural education, lessons need to be developed that expand students' ability to think through complex issues (Wells et al., 2015). Teachers interested in utilizing IBL methods should take a closer look into the evident benefits and find workshops to assist them with becoming more comfortable with the teaching method.

References

Desilver, D. (2017, February 15). *U.S. students' academic achievement still lags that of their peers in many other countries*. https://www.pewresearch.org/fact-tank/2017/02/15/u-s-students-internationally-math-science/

Dreifus, C. (2013, September 2). Ideas for improving science education in the U.S. *The New York Times*. https://www.nytimes.com/2013/09/03/science/ideas-for-improving-science-education-in-the-us.html

Eick, C. J., & Reed, C. J. (2002). What makes an inquiry-oriented science teacher? The influence of learning histories on student role identity and practice. *Science Teacher Education, 86*(3), 401–416. https://doi.org/10.1002/sce.10020

National Academy of Sciences. (2009). *Strengthening high school education through teacher outreach programs: A workshop summary to the Chemical Sciences Roundtable.* National Academies Press.

National Association of Agriculture Educators. (2019). *National Agriscience Teacher Ambassador program*. https://www.naae.org/profdevelopment/nataa.cfm

National FFA Organization. (2020). *Agricultural education: About FFA*. https://www.ffa.org/agricultural-education/

National Science Foundation. (2012). *How do U.S. 15-year-olds compare with students from other countries in math and science?* https://www.nsf.gov/nsb/sei/edTool/data/highschool-08.html

Parr, B. A., & Edwards, M. C. (2004). Inquiry-based instruction in secondary agricultural education: Problem-solving – An old friend revisited. *Journal of Agricultural Education, 45*(4), 106–117. https://doi.org/10.5032/jae.2004.04106

Shoulders, C. W., & Myers, B. E. (2011). An analysis of national agriscience teacher ambassadors' stages of concern regarding inquiry-based instruction. *Journal of Agricultural Education, 52*(2), 58–70. https://doi.org/10.5032/jae.2011.02058

Thoron, A. C., & Burleson, S. E. (2014). Students' perceptions of agriculture when taught through inquiry-based instruction. *Journal of Agriculture Education, 55*(1), 66–75. https://doi.org/10.5032/jae.2014.01066

Thoron, A. C., & Myers, B. E. (2012). Effects of inquiry-based agriscience instruction and subject matter-based instruction student argumentation skills. *Journal of Agricultural Education, 53*(2), 58–69. https://doi.org/10.5032/jae.2012.02058

Warner, A. J., & Myers, B. E. (2011, April). *What is inquiry-based instruction?* Universitiy of Florida/IFAS Extension. Retrieved February 2019, from Research Gate: https://www.researchgate.net/profile/Brian_Myers2/publication/237754159_What_Is_Inquiry-Based_Instruction1/links/00b4952cd9b3a2b934000000.pdf

Washburn, S. G., & Myers, B. E. (2010). Agriculture teacher perceptions of preparation to integrate science and their current use of inquiry based learning. *Journal of Agricultural Education, 51*(1), 88–98. https://doi.org/10.5032/jae.2010.01088

Weiman, C. (2012). Applying new research to improve science education. *Issues in Science and Technology, 29*(1). https://www.jstor.org/stable/43315691

Wells, T., Matthews, J., Caudle, L., Lunceford, C., Clement, B., & Anderson, R. (2015). The infusion of inquiry-based learning into school-based agricultural education: A review of literature. *Journal of Agricultural Education, 56*(4), 170–182. https://doi.org/10.5032/jae.2015.04170

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