Integrated STEM and poultry science curriculum to increase agricultural literacy

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ABSTRACT The shortage of graduates pursuing careers in the poultry industry is linked to a low awareness and lack of interest. Increasing agricultural literacy could promote engagement in future poultry science opportunities. We developed an integrated STEM curriculum within a poultry science context to assess the program’s impact on students’ agricultural literacy development. The Elementary Education Gain Grow (E.G.G.) program consists of 5 online modules, an interactive notebook, a simulation game, and a team project. In fall 2019, 480 Indiana 4th and 5th grade students enrolled in the pilot program. A 14-point poultry content-based questionnaire was administered online to students prior to program engagement, between online and team project activities, and at program completion. Student content scores (n = 111; 23.13% response rate) increased from 7.99 (SD = 1.85) preprogram to 9.76 (SD = 2.44) post online modules (P < 0.05; Cohen’s d = 0.82) and remained constant throughout the remainder of the program. Student notebook responses (n = 172; 35.83% response rate) provided qualitative data of their self-reported agricultural literacy gains and revealed patterns of increased agricultural literacy relating to the program’s learning objectives. These results support the program’s ability to increase student agricultural literacy. Teacher feedback (n = 9; 69.2% response rate) suggests that teachers agreed with the program’s effectiveness, with qualitative responses highlighting individual experiences. Our pilot program findings support the use of an integrated STEM and poultry science elementary curriculum to increase student agricultural literacy as well as demonstrate the effectiveness of the program as an educational resource.

Key words: agricultural literacy, STEM integration, poultry science, curriculum development

INTRODUCTION

Population growth increases the demand for animal protein, especially from poultry meat and egg production (FAO, 2017). In the last 20 yr, per capita egg consumption in the United States has increased over 16% (United Egg Producers, 2019). To support this growth, an increased number of skilled graduates are needed to fulfill jobs in the poultry industry. Currently, the United States agriculture, food, and natural resources annual job openings are estimated to be around 59,400 but only 61% are expected to be filled by college graduates with expertise in these areas (Fernandez et al., 2020). While the population and food demand grow, inevitable urbanization continues to distance consumers from food production (American Farm Bureau Foundation for Agriculture, 2012).

Though a large percentage of consumers are removed from agricultural practices, their demands are driving legislative changes to increase national production; in particular, of cage-free eggs by 2025 (Toffel and Van Sice, 2010; Ochs et al., 2019). Professionals within the egg industry agree that the switch to cage-free egg production will require 3 to 5 times more labor, which will contribute to the egg industry’s workforce shortage (O’Keefe, 2018). Limited awareness of the egg industry, as one sector within the broader poultry industry, impacts consumer demand and also public interest and perception of future career opportunities.

In the context of food animal production, agricultural literacy includes understanding the uses and roles of animals, animal welfare and husbandry practices, the effect of production practices on prices, the importance of processing, food safety, and product development and technology (Frick et al., 1991). In the context of the table egg industry, agricultural literacy includes consumers’ ability to explain the steps and purpose behind practices to produce eggs. Knowledge of these...
components is required for a person to communicate effectively about agriculture and be considered agriculturally literate (Spielmaker and Leising, 2013). Spielmaker and Leising (2013), along with The National Center for Agricultural Literacy, identified 5 agricultural sector themes that formed The National Agricultural Literacy Outcomes (NALOs). These themes have learning outcomes that target K-12 students and are used to assess student agricultural literacy and assist in aligning content to other academic domains. To increase agricultural literacy, it is crucial not only to have learning outcomes, but also to have a framework to successfully implement the outcome within an educational environment (Roberts and Ball, 2009). Implementing agriculture in the classroom allows instructors to foster real-world application and improve academic success in students, while using agriculture as the content focus to promote agriculturally literate consumers. Additionally, elementary teachers may find value in integrating agriculture as a context for traditional STEM academics (Knobloch et al., 2007).

Therefore, the purpose of our study was to develop an implementable integrated STEM curriculum that focused on developing student agricultural literacy around the egg industry. The Elementary Educate Gain Grow (E.G.G.) program provides teachers with the tools needed to include information on the table egg industry in the classroom. The present research was guided by the following objectives: 1) assess student agricultural literacy of the egg industry prior, during, and after the Elementary E.G.G. program; 2) explore patterns of student self-reported gained agricultural literacy; and 3) describe teacher perceptions of the Elementary E.G.G. program’s instructional design and effectiveness.

MATERIALS AND METHODS

Instructional Design

We developed the Elementary E.G.G. program to meet the academic standards of the targeted population. Indiana was selected due to our location within the state and because the state nationally ranks third in table egg production. The curriculum was designed to be used in both 4th and 5th grade classrooms. This allowed state standards and program objectives to be integrated into the context of the table egg industry. Required STEM skills were presented in the real-world context of the egg industry in order to help students see application of skills while developing agricultural literacy. Integrating STEM academics and agriculture prepares students for ever-growing workforce opportunities, equips them with the ability to thrive in our global economy and society, and improves achievement across disciplines (Altbach and Knight, 2007; Roberts et al., 2016; Wang and Knobloch, 2018). To uniformly assess agricultural literacy, the NALOs were utilized (Spielmaker and Leising, 2013). The NALOs have a similar structure to Indiana’s academic standards, which are encouraged to be used as the foundation of curriculum development so students can pass required standardized tests. Therefore, the Elementary E.G.G. program’s learning outcomes were aligned with the NALOs and Indiana Academic Standards. Additionally, we provided examples of STEM skills utilized within each module and corresponding outcomes. With these alignments we provided an implementable curriculum for Indiana 4th and 5th grade classrooms.

The Elementary E.G.G. program curriculum was developed to be implemented in 2 components that together created a 10 consecutive day unit with 45 min of student engagement per day. The first part (d 1 to 5) consisted of 5 online modules which included an embedded simulation game and supplemental interactive notebook. Students completed one module each day. The second portion (d 6 to 10) encompassed a team project which had students apply previously introduced outcomes and skills. All content was reviewed by the program’s advisory panel which consisted of 2 industry professionals and 2 current Indiana 4th grade teachers not enrolled in our pilot program.

Online Modules An online setting was selected because it allowed more students to be reached in a consistent manner. The program’s 5 online modules focused on various aspects of the egg industry in order to expose students to multiple sectors of the industry (Table 1). Module content and interactive features were externalized on Storyline 360 Software (Articulate 360, New York, NY). Students were challenged to apply STEM skills and concepts during their exposure to the egg industry.

The ARCS model, a learning motivation theory, was used as the framework for module formatting and encouraging student interaction with the online environments (Keller, 1987). Table 1 contains examples of features that are designed to align with the ARCS model. Student motivation is heightened by utilizing the ARCS model’s 4 crucial factors: Attention, Relevance, Confidence, and Satisfaction. For example, we utilized visuals and supplemental audio to capture students’ attention while the real-world context and age appropriate examples aimed to increase content relevance. Students received feedback and encouragement as they navigated tasks to support their confidence. Additionally, all tasks had a goal and student satisfaction was promoted by aligning rewards with completion of activities. Applying the ARCS model to agricultural STEM curricula can promote student success, awareness and interest in agricultural industries, and encourage development of agricultural literacy (Erickson et al., 2019; Roberts and Ball, 2009).

Simulation Game Additionally, a simulation game was developed using the ARCS model to align with the online module learning objectives. For example, interactive animations and character navigation supported attention and interactive text created relevance. The simulation game facilitated students’ exploration of a hen’s digestive system to learn about organs and the importance of nutrition in egg development.
Table 1. Overview of online module topics, learning objectives, content, and features.

| Module | topic                        | Learning objectives                                                                 | Content                     | Features                                |
|--------|------------------------------|-------------------------------------------------------------------------------------|-----------------------------|-----------------------------------------|
| 1      | Introduction: The Table Egg Industry | Explain the history of the egg industry (Nationally, Midwest, and within Indiana) Identify basic life stages of hens in modern day laying hen industry | Navigation Tutorial History of the Hen | Interactive text and character dialog Interactive diagrams |
| 2      | Production: From Farm to Fork  | Explain the main steps and locations needed to produce a table egg Describe and differentiate hen housing systems Define the common types of table eggs | Steps in Production Egg Labeling | Drag and drop activity Interactive text |
| 3      | Laying Hens: Anatomy and Physiology | Identify the basic steps and purpose of the digestive and reproductive system of a laying hen Describe ways a farmer can choose genetic traits Connect how genetics can affect egg production | Digestive System Simulation Traits in Chickens | Interactive text, character dialog, and animation Interactive text and interactive diagrams |
| 4      | Animal Welfare: Caring for Hens | Define animal welfare and identify the “Five Freedoms” Describe the purpose of taking care of laying hens Identify basic ways to make sure laying hens are being cared for with connection to the “Five Freedoms” | Animal Welfare Filling the Five Freedoms | Interactive text Drag and drop activity |

Modules were completed for 5 consecutive days at the beginning of the Elementary E.G.G. program.

To incorporate student interaction, students were posed with questions that required them to investigate the online environment and interact with developed simulation characters. To begin their mission, students selected a representative “feed character” and then navigated the character through the hen’s digestive tract. Students could select from one of 3 cartoon characters: corn, soybean, or wheat. Questions and observations allowed students to successfully complete one organ and unlock the next organ in the digestive tract.

Interactive Notebook The ability of students to apply skills beyond an online environment is critical to develop a connection to the content. Interactive notebooks are one way to build connections with the material and to promote learner-centered teaching strategies (Knoebloch, 2010, slide 14). The use of notebooks improves learning outcomes for audiences from kindergarten to adulthood (Klentschy, 2008). This tool is interactive by prompting students to reflect, design, record, or interpret information that is connected to their current learning environment (Aschbacher and Alonzo, 2011; Science Scope, 2003). Specifically, for elementary students, interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experience (Klentschy, 2008; Science Scope, 2003). In our Elementary E.G.G. program, each student was provided a paper notebook that was aligned specifically to prompts and tasks described in the online modules. Before each module, there was a prediction page with 5 open ended prompts targeting either student prior interest or knowledge on the module’s topic. At the end of each module and at the completion of the program, there were conclusion pages with 5 prompts to facilitate students’ reflection and connection with their learning experience. These pages encouraged further engagement by students while completing the online modules.

Team Project Collaboration with peers can foster critical thinking and problem-solving skills, which are crucial to STEM success and useful skills outside of academia (Reeve, 2015; Yuen et al., 2014). The Process Oriented Guided Inquiry Learning (POGIL) method is designed to support inquiry-based collaborative learning experiences (The POGIL Project, 2019). Our program utilized this method to assign students a role within their team and to establish an environment for productive collaboration. By assigning roles, students are given clear objectives, personal responsibility, and the ability to examine creative solutions. This is especially beneficial for upper elementary students, who developmentally seek peer approval and are beginning to master recognizing others’ needs along with their own responsibility (Ormrod and Jones, 2015). Providing teachers with POGIL roles and grouping guidelines also aided in maintaining some level of comparability of team project experiences by providing uniform procedures and objectives across classrooms. Teachers were instructed to assign 3 to 4 members per team and assign each member one of the following roles: 1) recorder, 2) checker, 3) manager, and 4) technician. In the event that the team only had 3 members, the technician role was not filled.
We instructed teachers to implement the team project right after the online modules (d 6 to 10 of program) and to select teams to be equal in strength and likelihood of success. The project objective was to have teams design an economically successful laying hen facility that maintained high animal welfare through multiple decisions then present their facility to the class. This goal was accomplished if students stayed within budget and could justify their decisions based on supportive evidence provided or learned in the modules. Making these decisions allowed students to apply the learning outcomes previously presented in the online modules. Teams progressed through 3 phases to reach the main goal: 1) decisions (d 6 to 7); 2) construction (d 8 to 9); and 3) presentation (d 10). At the completion of the team project, students completed a self and peer evaluation form.

**Population and Participants**

Recruitment efforts consisted of emailing informational flyers with an active webinar link over appropriate listservs, emailing Indiana elementary or intermediate school principals (publicly available on the Indiana Department of Education website), and presenting the enrollment opportunity at a summer teacher workshop. Teachers were selected on a first come basis until the predetermined limit of 500 students or the deadline of July 2019 was met. Enrollment closed with 480 students across 17 classrooms (13 teachers, with 1 teacher in 3 classrooms, 2 teachers in 2 classrooms, and 10 teachers in one classroom). There was an average of 24 students (SD = 5.40) per classroom, which was distributed across 8 different Indiana school districts. After enrolling in the Elementary E.G.G. program, teachers participated in an in-person 30-min facilitator training. During the training we provided a program overview, outlined requested materials for research purposes, practiced navigation of the online platform, and ended with an open question segment. After the completion of the in-person training, teachers were encouraged to implement the program between September and December 2019.

**Study Design**

The university institutional review board approved all study procedures (IRB #1906022309). The Elementary E.G.G. program used mixed methods to collect data to evaluate the program’s impact on student agricultural literacy and teacher experience. We studied the impact of the program on the development of student agricultural literacy and teacher perceptions of the program’s effectiveness and implementation. Content knowledge questions were evaluated by a panel of experts including elementary school teachers and poultry industry representatives. Questions assessing teacher perception were evaluated by 6 elementary school teachers not enrolled in the program.

**Instrumentation**

Student agricultural literacy development was assessed 3 times throughout the program: 1) immediately before starting online modules (preprogram); 2) immediately after completion of the online modules (postmodules); and 3) immediately following completion of the team project (postprogram). The content assessments consisted of 14 multiple choice or true and false questions and were created to align with the program’s learning outcomes. Students were unaware of personal content scores and all assessments were administered online using Qualtrics Survey Software.

Qualitative data from student notebook pages were coded to gain insight into student agricultural literacy patterns relating to the modules (Feldman et al., 2018). After each module, students completed one to 3 open-ended questions that prompted them to reflect on the experience. Enrolled teachers manually mailed or electronically scanned or faxed in the student notebook pages in order to return responses to researchers by program completion. Student responses were manually compiled in Microsoft Excel® for electronic organization and storage.

Teacher feedback was solicited by administering an online questionnaire via Qualtrics Survey Software. The questionnaire consisted of 10 agreement scale questions (Range 0–100; 0 = disagree; 100 = agree) and 3 open-ended questions. The 10 agreement scale questions focused on the program’s implementability, benefit to students, and value as an integrated STEM curriculum. Teacher open ended responses were compiled into Microsoft Excel.

**Quantitative Analysis**

We completed all quantitative analysis using IBM SPSS Version 26 software. Only data that were collected correctly and completely across all assessments from students and corresponding classrooms were used for analysis. Post hoc Tukey’s tests compared preprogram, postmodule, and postprogram content scores. We calculated Cohen’s d to represent the effect size of statistically significant results. ANOVAs were used to assess teacher effect, with classroom as a nested variable, on content scores. Additionally, an ANOVA compared teacher agreement across program feedback responses. For all analyses, we declared significance at $P < 0.05$.

**Qualitative Analysis**

Qualitative data from student notebooks and teacher responses were analyzed following the inductive qualitative data coding method (Feldman, 2018). To support our qualitative content analysis, we implemented a previously validated checklist developed in 2014 to ensure proper analysis throughout the preparation, organization, and reporting phase (Elo et. al., 2014). In this manner, useable responses from student notebook conclusion pages regarding students’ agricultural literacy were collected. These responses were from selected predetermined prompts, one per module. Responses were then coded to explore what impact the program had on student agricultural literacy patterns associated with each module and
overall program. Similarly, teachers’ responses to the 3 open ended prompts were coded into themes to better showcase teacher feedback. Prompts specifically asked about program components, observed student experience, and suggestions for future development.

RESULTS

Quantitative Agricultural Literacy Results

Objective 1: Evaluate changes in student knowledge prior to, during, and after the Elementary E.G.G. program. The preprogram, postmodule, and postprogram assessments were scored based on the number of correct answers out of the 14 questions. Only students who completed all 3 assessments were included in the analysis (n = 111; 23.1% response rate). Students answered more questions correctly at the postmodule compared with the preprogram assessments (9.76 ± 0.30 vs. 7.99 ± 0.30; P < 0.05; d = 0.82) (Table 2). The gains seen in the postmodule assessment (9.76 ± 0.30) were sustained throughout the team project and were captured in the postprogram assessment (10.05 ± 0.30). The number of correctly answered questions indicates that students learned the content during the online modules and were able to retain this knowledge as they applied the information in the team project.

An ANOVA was conducted to explore the effect of classroom on student content knowledge with classroom nested within teacher since all but 3 teachers had only one classroom. Classrooms (n = 10; 52.63% response rate) that had complete and correct data for all 3 content assessments were used in the analysis. Classroom had an effect (P = 0.008) on student content scores, suggesting differences in the classroom environments did influence the program’s impact on student agricultural literacy.

Qualitative Agricultural Literacy Results

Objective 2: Explore patterns of student self-reported gained agricultural literacy. By inductively coding student qualitative notebook responses, we developed patterns of students’ self-reported agricultural literacy gains across modules (Table 3). Student responses were in reference to prompts that targeted students communicating what they learned from each module and the entire program. We could only match notebook pages to a classroom and not an individual student because student names were deidentified by teachers before being returned. Therefore, if a classroom (n = 10; 52.63% response rate) had at least one correct and complete student response for content score, the notebook written responses were analyzed for students in the class who completed all of the notebook written responses. (n = 172; 35.8% response rate). Notebook responses exhibited patterns of students’ agricultural literacy consistent with module learning objectives. Students self-reported learning patterns that were identified by our research team as critical learning outcomes for the Elementary E.G.G. program (Table 3). Student responses provided evidence of comprehension of the main topics within each module. Several topics, such as anatomy and animal welfare, appeared multiple times in the responses, indicating an increase in awareness of the topics.

Table 2. ANOVA comparison of mean student scores administered preprogram, postmodule, and postprogram assessment.

|                | Mean | SD  | Cohen’s d |
|----------------|------|-----|-----------|
| Preprogram     | 7.99 | 1.85| 0.82      |
| Postmodule     | 9.76 | 2.44|           |
| Content postprogram | 10.05 | 2.43|           |

Subscripts indicate statistical differences among content score means.

n = 111; P < 0.05.

n = 172; 35.8% response rate.

Table 3. Agricultural literacy patterns observed from student interactive notebook responses.

| Module | Prompt                                                                 | Pattern           | Example student quotes                                                                 |
|--------|------------------------------------------------------------------------|-------------------|----------------------------------------------------------------------------------------|
| 1      | “In this module, three things that I learned were…”                    | Industry scope    | “Midwest most eggs cause most access to corn and soybean”                              |
|        |                                                                        | Life stages       | “Life cycle of a chicken”                                                              |
|        |                                                                        | History           | “Brought by ships over 500 years ago”                                                  |
| 2      | “From this module the two things I learned the most about were…”      | Housing systems   | “What cages they stay in and what they do in each different cage”                      |
|        |                                                                        | Processing        | “A lot of steps to get eggs in your fridge”                                             |
| 3      | “The most important thing I learned about laying hens in the module is…” | Hen anatomy       | “Digestive parts of the hen”                                                           |
|        |                                                                        | Comparing eggs    | “If the laying hen has no rooster the egg will not hatch”                              |
| 4      | “In this module I was surprised to learn…”                             | Animal welfare    | “Welfare helps makes hens healthier”                                                    |
| 5      | “What is one thing about eggs that I now know that I did not know before?” | Egg anatomy       | “That the white stuff inside an egg is called albumen”                                 |
| Overall| “The most important information that I learned in this program was…”   | Animal welfare    | “That chickens have five freedoms and their welfare is important to produce eggs”       |
|        |                                                                        | Hen anatomy       | “How the egg comes out of the chicken”                                                  |
Students could complete the program as designed or with minor adjustments. Students seemed to feel capable of implementing the program into my classroom. The program was able to be implemented with moderate simplicity and convenience. The notebook was a useful resource for students during the online modules. The notebook was a useful resource for students to refer to during the team project.

Table 4. Teacher mean agreement scores to program statements on usability, curriculum value, and student benefit (n = 9).

| Statement                                                                 | Mean agreement score$^1$ (Min; Max)$^2$ | df |
|---------------------------------------------------------------------------|----------------------------------------|----|
| I would recommend others to enroll in the program.                        | 77.11 (40;100)                         | 9  |
| The program aligned with the provided state academic standards.           | 83.67 (30;100)                         |    |
| The program added educational benefit to the students learning; students showed improvement and growth. | 76.33 (10;100)                         |    |
| The program is a valuable STEM curriculum resource.                       | 77.00 (25;100)                         |    |
| The in-person training and teacher manual allowed me to feel capable of implementing the program into my classroom. | 89.44 (70;100)                         |    |
| The program was able to be implemented with moderate simplicity and convenience. | 77.56 (29;100)                         |    |
| The notebook was a useful resource for students during the online modules. | 88.11 (60;100)                         |    |
| The notebook was a useful resource for students to refer to during the team project. | 78.67 (50;100)                         |    |
| Students seemed to find curriculum interesting and engaging.              | 83.00 (50;100)                         |    |
| Students could complete the program as designed or with minor adjustments.| 81.39 (10;100)                         |    |

$^1$Scale range 0–100; 0 = disagree; 100 = agree.
$^2$Range of responses for each statement.

## Qualitative and Quantitative Teacher Feedback

Objective 3: Describe teacher perceptions of the Elementary E.G.G. program’s instructional design and effectiveness. Quantitative data of teacher feedback (n = 9, 69.2% response rate) indicated that on average teachers agreed with statements about the program in relation to its usability, curriculum value, and student benefit (Table 4). Overall, individual teachers had different statement agreement means when comparing across all statements ($P < 0.05$). The majority of teachers (66.7%) reported high individual agreement to all of the statements (scores above 75), 2 (22.2%) were identified with low agreement (below 75 but above 25) and one teacher (11.1%) fell into the neutral to low disagreement quartile (below 50 but above 25).

When comparing themes of teacher responses to open ended prompts, there once again was an overall positive tone to program effectiveness. There were no consistencies in causes or suggested improvements on the part of the teachers who reported frustration of displeasure with the program (Table 5). Inductive qualitative data coding indicated that teachers agreed that each of the components supported learning and a positive student program experience. However, there was limited agreement on possible improvements, indicating that each teacher inevitably encountered unique challenges within their classroom and group of students. For example, one teacher mentioned students could not cope with the complexity of the team project while others praised the program’s challenge level and voiced student favoritism toward the team project component. Additionally, one teacher suggested more online components could aid in supporting a wider range of students’ abilities while another voiced that their frustration was connected to online issues.

### DISCUSSION

Students in our study learned the majority of content during the online modules. A study utilizing an integrated STEM and poultry science curriculum reported that online modules improved high school students’ knowledge of poultry science (Erickson et al., 2019). However, results from the Erickson et al. (2019) study suggest that additional engagement, beyond the online resources, may benefit the overall student learning experience. Our elementary E.G.G. program included a team project to provide students with an authentic, real-world experience related to the poultry content presented in the online modules. Though student poultry science knowledge was sustained throughout the program, the theoretical framework of STEM-integration would suggest that the additional application of knowledge in a team problem-based project would have the potential for additional agricultural literacy growth (Kontra et al., 2015; Wang and Knobloch, 2018).

Additionally, the interactive notebook was utilized as a supplemental resource to the online modules and may have indirectly influenced student content knowledge. Interactive notebooks have been used successfully to

Table 5. Teacher feedback in relation to prompts (n = 9).

| Prompt                                                                 | Common theme       | Percent (%) coded into theme |
|------------------------------------------------------------------------|--------------------|------------------------------|
| “Did you feel the three components of the program (online, notebook, and team project) worked together to increase student engagement? Why or why not?” | Yes - improved learning | 77.78                        |
| “What are three words/phrases you would use to describe students’ experience when engaging with the program?” | Interesting        | 66.67                        |
| “How would you suggest the program be edited to better meet the needs of all students who have varying ability levels?” | Adjust challenge level | 33.33                        |
improve learning outcomes for audiences from kindergarten to adulthood (Klentschy, 2008). Specifically, for elementary students, interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experiences to connect more meaningfully with the content and elementary students, interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experiences to connect more meaningfully with the content and elementary students, interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experiences to connect more meaningfully with the content and elementary students, interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experiences to connect more meaningfully with the content and elementary students, interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experiences to connect more meaningfully with the content and elementary students, interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experiences to connect more meaningfully with the content and elementary students, interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experiences to connect more meaningfully with the content and elementary students, interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experiences to connect more meaningfully with the content and elementary students, interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experiences to connect more meaningfully with the content and elementary students, interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experiences to connect more meaningfully with the content and elementary students, interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experiences to connect more meaningfully with the content and elementary students, interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experiences to connect more meaningfully with the content and elementary students, interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experiences to connect more meaningfully with the content and elementary students, interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experiences to connect more meaningfully with the content and elementary students, interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experiences to connect more meaningfully with the content and elementary students, interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experiences to connect more meaningfully with the content. Therefore, the notebook had the potential to further engage students while they completed the online modules.

In our study, the patterns coded from student notebook responses relating to gained content knowledge often reflected the corresponding modules’ learning objectives. This suggests that students were able to discern the main objectives within each module which were aligned to NALOs. The aligned NALOs were specially designed to match the targeted age group’s comprehension ability and academic standards (Spelierman and Leising, 2013). This alignment allowed students to identify and learn the agricultural literacy objectives. However, topics such as anatomy and animal welfare appeared in multiple module prompts, supporting that students may have retained more knowledge about these topics. Increased knowledge and academic achievement are closely related to the learner’s interest and motivation to learn (Hidi and Harackiewicz, 2000; Ryan and Deci, 2000). Students might recall content knowledge relating hen and egg anatomy along with animal welfare because they had higher interest in these topics. Research focusing on interest in specific animal science or poultry science topics is limited, with most examples from secondary educational classrooms. However, student interest is related to their previous experiences (Hazel et al., 2011; Reiling et al., 2003).

There was a classroom effect on change in student content knowledge scores. Students’ learning environment can predict student engagement and academic motivation (Wang and Eccles, 2013). Furthermore, students’ engagement and motivation to further interact with the academic content were found to be associated with academic achievement (Wang and Eccles, 2013). These findings may help explain why some classroom environments within our study were found to have significantly different agricultural literacy scores. Though every classroom was provided the same program materials and instructional training, there are unique environmental factors, including teacher or peer interactions along with physical attributes of each classroom that can have an impact on student learning. Years of teaching experience can also influence student learning. These factors may alter the environment enough that students could have different experiences when engaging with the same program and therefore influence their learning experience differently. Individual teachers may have differing facilitation strategies or conceptual connection to the same instruction material which then affects the learning experience they provide (Diefes-Dux, 2015).

As a group, teachers in the E.G.G. program self-reported a positive experience implementing the program in relation to its usability, curriculum value, and student benefits. Elementary teachers have reported adding agriculture as the context for a lesson as being a strategy to integrate multiple academic domains (Knobloch and Martin, 2002a, 2002b; Humphrey et al., 1994). Additionally, elementary teachers want agricultural resources with developed lessons relating to required academic standards and in-class activities (Knobloch et al., 2007), both of which our program provided. Teacher feelings of competency in a subject has previously been shown to impact student learning experience and self-efficacy during program implementation (Erickson et al., 2019). Teachers in our Elementary E.G.G program reported feeling capable of implementing the program in their classroom. Unlike in the Erickson et al. (2019) study, teachers in our program received in-person training prior to implementing the program in their classroom. Teacher preparation is crucial when implementing an integrated STEM curriculum (Eijwale, 2013; Robinson and Edwards, 2012). However, some teachers in our study experienced frustrations related to their unique challenges when implementing the Elementary E.G.G. program in the classroom. Inconsistencies between educator experiences have been found to exist when teachers are asked to explain why they might not teach or have difficulty teaching agriculture in elementary schools (Knobloch et al., 2007). Additional research has investigated the level of concerns elementary teachers had in relation to an agricultural literacy curriculum (Bellah and Dyer, 2007). Individual teachers’ highest ranked concerns were much less homogeneous than the potential benefits provided by the same teachers (Bellah and Dyer, 2007). These findings suggest concurrency with our teacher feedback trends. Teachers involved in our study were able to uniformly identify what they agreed with or had positive experiences with, but when frustrations were voiced, there was little consistency.

**Limitations**

Despite in-person teacher trainings, facilitation guides, and teacher access to the researchers, not all classrooms completed all program assessments. Only data collected from students who completed all assessments were included in the program results. Therefore, our program experienced a student response rate of 23.13% for content scores and 35.83% response rate for notebook responses. This variation is due to the approved protocol of notebooks only being connected to classrooms, not individual students. We did attempt to increase response rate by communicating with teachers throughout the program and we were readily available to answer teachers’ questions and concerns. Additionally, we were not able to collect longitudinal data on the long-term sustainability of poultry science knowledge as
a result of completion of our program. The students and teachers were also from a self-selected convenience sample with all schools located in Indiana. Limits in the research design prevent causal inference of results without further investigation in variation of learning environments. Content knowledge assessments may be subjected to habituation effects, but student lack of awareness of content scores aimed to enhance the validity due to lower achievement anxiety (Cassady, 2004). At last, multiple modes of data collection and less than 25% response rates lead to some restriction when transferring findings outside of the piloted sample group’s experience. Our different response rates across the different modes of collection (i.e., online for content assessments and traditional paper for notebook responses) are congruent with a previous study that had the highest response rate via paper responses and lower on web-based responses (Fraze et al., 2003). The study concluded that there was no significant difference in response reliability between the different collection methods and the different response rates (Fraze et al., 2003). In the future, a bimodel method, the use of multiple types of collection to assess the same research question, mathematically exploring nonresponse biases, and the use of statistically validated steps to generate possible responses could help combat and justify claims from results of future programs since our pilot program’s framework indicates success within our student sample (Fraze et al., 2003; Phillips, 2016).

**Recommendations**

Further research is needed to understand how to better integrate STEM and agriculture into a curriculum that is used across multiple learning environments. Recently, an objective rubric to assess STEM integrated lessons was developed by Wang and Knobloch (2018). This rubric can be utilized by teachers when providing feedback on the level of integrated STEM lessons to help improve teacher feedback usability and increase consistency. The lowest level (exploring) represents clear separation of the domains (i.e., science, technology, engineering, mathematics, and agriculture) while the highest level (advancing) blurs which domains are being applied to solve real-world problems. Even though teacher experiences may be unique, the rubric descriptions and levels are consistent and therefore help teachers more precisely indicate where the curriculum needs improvement with less interpretation by the researcher. Increasing teacher feedback will allow for adjusting future programming for a wider range of audiences.

**CONCLUSION**

The Elementary E.G.G. program improved student agricultural literacy. Students in our program reported learning the most about topics that directly aligned with the program’s learning objectives and with areas relating to hen anatomy and welfare. Collaborative team projects immediately following the online modules provided an authentic learning experience and real-world application, and enabled retention of knowledge gained from the online modules. Teacher feedback supported the program’s ability to be successfully implemented within our sample classrooms with a couple individual teachers voicing unique frustrations. Future research is needed to improve suitability of teacher feedback by possibly implementing rubrics for teachers to utilize when providing feedback, which could improve usability of comments that specifically reflect individual experiences and limit interpretation bias. Lastly, increasing the response rates through teacher and student compliance will help improve similar programs’ distribution ability nationally and across other age groups.

**DISCLOSURES**

No conflicts of interest to declare for this manuscript.

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