THE ELEMENTARY E.G.G. PROGRAM IMPACT ON AGRICULTURAL LITERACY AND INTEREST

by

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Dedicated to Samantha^2, Henry, and Willie for always being a source of motivation.

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ABSTRACT

This thesis examines the Elementary Educate Gain Grow (E.G.G.) program and its impact on student agricultural literacy and interest in relation to the program's pilot classroom implementation. The overall shortage of graduates pursuing careers in the poultry industry was the motivation behind the program development. The gap between industry demand and the potential entering poultry workforce may be linked to low awareness and interest relating to poultry science. This is particularly true in the egg industry. As consumer and legislature demands continue to affect egg production practices and demand for eggs continues to grow, it is especially crucial for consumers to become more aware of industry practices. One way to increase awareness may be to include educational resources within the K-12 system that are designed to increase awareness and interest in the industry. By integrating poultry science into required academic standards, students are given a real-world context to apply STEM skills. This has the potential to improve the learning experience and stimulate student interest and awareness. Such resources have the potential to promote future student engagement in poultry science opportunities. Therefore, the Elementary E.G.G. program was developed as an integrated STEM and poultry science curriculum with five online modules, a supplemental interactive notebook, an embedded simulation game, and a final team project as a resource for upper elementary teachers and students. All content and materials were developed between fall 2018 and summer 2019 and were made available to 480 Indiana 4th and 5th graders (13 teachers, 19 classrooms) across 8 different school districts in the fall of 2019. The program was designed for a ten consecutive day STEM unit starting with online modules (days 1 to 5) and followed by a team project (days 6 to 10). There were three overall research questions to assess the impact of the Elementary E.G.G. program: 1) what was student agricultural literacy before, during, and after program implementation; 2) did the program have an effect on student situational interest; and 3) what was the teacher perceived value and effectiveness of the program as an education resource.

Chapter One provides a literature review outlining past research that provided background for the development of the Elementary E.G.G. program.

Chapter Two describes the experimental methods and results of the piloted Elementary E.G.G. program and how it impacted student agricultural literacy through evaluating three content assessments and student notebook responses. Additionally, we discuss teacher feedback, collected

at the completion of the program. Quantitative data was collected to assess student poultry knowledge prior (pre-program), during (post-modules), and after implementation (post-program) using 14 multiple choices questions focused on module content. The questions were administered online using Qualtrics (Qualtrics, Provo, UT). Only student data that was completed correctly across all assessments and notebook responses from student's in corresponding classrooms to the other assessments were used for analysis. Student notebook responses from 10 corresponding classrooms (52.63% response rate), were deemed usable for analysis since these classrooms had students who correctly completed all assessments and qualitative data from notebook responses could only be matched to classrooms not individual students. Student content scores (n=111; 23.13% response rate) were analyzed using an ANOVA post hoc Tukey's test with SPSS Version 26. Content knowledge scores increased from 7.99 (SD=1.85) during the pre-program assessment to 9.76 (SD=2.44) post-modules ($p < 0.0001$). Student notebook responses provided qualitative data of their agricultural literacy development throughout the modules. Student responses from the useable 10 classrooms (n=172; 35.83% response rate) were inductively coded to reveal patterns that supported increased student agricultural literacy related to each module's predetermined learning objectives. The increase in content scores along with student identification of learning objectives support the program's ability to increase student agricultural literacy. Teacher feedback (n=9; 69.2% response rate) indicated that teachers agreed that each of the components (modules, notebook and team project) supported the program objectives and the majority reported that the program encouraged student participation and interest. We concluded that the E.G.G. program increased student content knowledge of the poultry industry and was a viewed as an implementable curriculum by teachers.

Chapter Three shares the program's procedures and results in relation to student situational interest during the program's implementation. A pre-program questionnaire assessed student individual interest scores while post-module and post-program assessments evaluated student situational interest (n=111; 23.1% response rate). Increased individual interest scores (3.57± 0.10) may indicate a higher likelihood of having situational interest stimulated (scale: 1 to 5 with 1 having no interest and 5 having the highest level of individual interest). Results support that the online modules and the team project stimulated student situational interest because total situational interest scores, in addition to each individual subscale (i.e. attention, challenge, exploration, enjoyment, and novelty), were above a two on a four point Likert scale (scale: 1 to 4 with 1 having no situational interest during the activity and 4 having situational interest fully induced). Previous validation of this assessment interprets subscale or total scores above a two to represent that students are experiencing situational interest during the activity in question. Attention, challenge, novelty, and overall situational interest scores were significantly higher during the team project compared to the online modules ($p < 0.01$) while exploration and enjoyment subscales were similar. Student interest themes, coded from their notebook responses, showed interest in the modules' learning objective topics with students demonstrating repeated interest in egg and hen anatomy and animal welfare. Overall, student situational interest was stimulated by the Elementary E.G.G. program, with overall interest highest during the team project compared with the online modules. Furthermore, students self-reported having interest in topics aligned with the modules' learning objectives and inductive coding of responses found reappearing themes of interest relating to hen anatomy and animal welfare.

In conclusion, the results from the pilot Elementary E.G.G. program support that an integrated STEM and poultry science elementary curriculum has the potential to increase student agricultural literacy and can successfully impact student situational interest by engaging in purposefully developed activities. Further research is needed to adopt a framework across other poultry science sectors at a national level and improve accessibility of materials to a wider target audience. Additionally, improvements in program compliance may aid in increasing response rates of such research and are needed to increase transferability of findings.

CHAPTER 1. LITERATURE REVIEW

1.1 Egg Industry: Importance and Challenges

As the global population increases, the demand for animal protein from poultry and eggs continues to grow (FAO, 2017; The Meat Site, 2015). The United States production of table eggs and egg products annually generates $29.29 billion in economic activity and provides $6.3 billion in wages (United Egg Producers, 2019). The Midwestern U.S. states of Indiana, Iowa, Ohio, and Michigan, represent over half the top seven egg producing states, with Indiana being ranked third nationally (USDA, NASS, 2019). Indiana's table egg industry offers more than 5,000 jobs throughout the state with an estimated 2,700 new jobs possible with the addition of new egg operations (Dunham & Associates, 2018; Indiana Business Research Center, 2017). Indiana's egg industry continues to grow, as it generated over 1 billion dollars in sales in 2015, almost doubling in size since 2008 (Indiana Business Research Center, 2017). However, the annual job openings in the United States Agriculture, Food, and Natural Resources (AFNR) are estimated at 57,900, with only 61% expected to be filled by college graduates with aligned field expertise (Goecker et. al., 2015). The egg industry is a prime example with insufficient numbers of college graduates interested in entering the egg industry workforce to meet the growing employment demands at either the state or national level (Paul Brennan, Executive Director Indiana State Poultry Association, personal communication).

Within the last decade, there has been a public effort to evaluate the animal agriculture production sectors in relation to animal welfare, especially within the table egg industry, which includes the raising and management of laying hens (Nolen, 2012; Hartcher & Jones, 2017). Nationally, consumer demand is driving legislative changes to increase production of cage-free eggs by 2025 (Toffel & Van Sice, 2010). Professionals within the egg industry agree that the switch to cage-free egg production will require three to five times more labor (Mullally & Lusk, 2017; O'Keefe, 2018). This transition will create an even greater deficit of qualified workers in the industry. Although consumers frequently drive the animal production changes, there is often a disconnect between the production practices and the public's understanding of these practices. The general public lacks basic knowledge and is unaware of the production steps and reasoning behind common practices within the egg industry (Malone & Lusk, 2016).

1.2 Importance of Agricultural Literacy

Population growth and urbanization continue to distance consumers from the production of food (American Farm Bureau Foundation for Agriculture [AFBFA], 2012; NRC, 1988). Limited awareness of the egg industry impacts interest and the perception of future career opportunities, which contributes to the egg industry's workforce shortage. Many consumers have little relation or understanding of how their food is produced and how the different processes affect prices and labeling (Lusk, 2010). The decreased personal connection increases the need for agricultural education as a means to increase agricultural literacy (NRC, 1988; Roberts et al., 2016). Agricultural literacy is a phrase used to describe a person's ability to communicate and analyze basic information about agriculture through their awareness and knowledge (Frick et al., 1991). Frick et al. (1991) further explains agriculture to be a broad term, with eleven sectors, that includes the production of animal products and processing of these products. For example, agriculture includes the egg industry raising the laying hens to produce the table eggs for human consumption. Continuing research has widened this initial definition to encompass beyond just concept knowledge and include critical analysis skills based on evidence and understanding value-based judgements (Powel et al., 2008). Therefore, agricultural literacy includes the consumers' ability to explain the steps and the purpose behind practices that produce table eggs and possibly why they support certain practices based on the evidence from their knowledge and values. It is important to note that a consumer's value can influence their judgement and being agricultural literate provides them the ability to discern their motive behind choices without misconception being the root motivation.

In the context of the egg industry, 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). These sectors and a multitude of other components can be found throughout different agricultural practices. Knowledge of these components is required for a person to communicate effectively about agriculture and be considered agriculturally literate (Spielmaker & Leising, 2014). Spielmaker and Leising, along with The National Center for Agricultural Literacy, identified five agricultural sector themes that formed The National Agricultural Literacy Outcomes (NALOs). These outcomes have application potential and learning objectives which target K-12 student development. Other organizations, such as the American Farm Bureau Foundation for Agriculture (AFBFA), also value the importance of creating educational frameworks for all general consumers to learn about agriculture and its current practices that produce the world's diversifying food, fiber, and energy supply (AFBFA, 2012). They have maintained an online public resource that outlines "The Pillars of Agricultural Literacy", which is marketed to educators, formal and nonformal, as a planning tool, a learning framework, and a guide to measure reference points and growth of agricultural literacy (AFBFA, 2012). Though the concept of integrating agricultural literacy into the United States education curriculum has been around since the organization of a formal educational system in the 1800s; the current general public's lack of direct relation to agriculture emphasizes the need to increase agricultural education in our modern day schools (McKim et al., 2017; Mondale & Patton, 2001; NRC, 1988).

In 2013, Kovar and Ball synthesized the previous two-decades worth of research that encompassed studies evaluating the goal and the target audiences of program interventions aiming to increase agricultural literacy. They found that although there were varying types of programs that target audiences from elementary schools to adults, the majority of the target populations were still "agriculturally illiterate" (Kovar & Ball, 2013). This demonstrates the continued need to develop programs and resources to integrate agricultural literacy in the United States' educational system.

The United States agricultural system has proven its successfulness by producing enough food at low costs with only 1% of our population physically farming (Goecker et al., 2010). However, if agriculture is going to continue to meet our local needs and address the global needs relating to production, quality, and environmental concerns, agriculture must be understood and valued by all (Roberts et al., 2016). This can start with consumer's having a better understanding of agriculture's scope and the reality of how food, fiber, and energy are produced (AFBFA, 2012). Knowledge of these systems (and the lack of knowledge) can influence the purchasing behavior of consumers (Brune et al., 2018). These consumer trends have demonstrated their power to influence global companies and even U.S. legislature, with the egg industry as a prime example (Malone & Lusk, 2016). Overall, increasing agricultural literacy can help bring awareness and possible increase the entering workforce to help solve agriculture's global challenges while promoting consumer education and critical thinking skills when discerning how to utilize their purchasing power.

1.3 Relationship Between Motivation and Interest

1.3.1 *Motivation*

Increasing agricultural literacy is only one of the many aspects that may facilitate greater involvement in the egg industry. In addition to awareness and knowledge, interest is also needed to further motivate engagement and possible career focus (Lent et. al., 1994). The relationship between motivation and individual interest is complex. Theorists still debate if motivation or individual interest precedes the other in comparable relation to the "chicken or the egg" conundrum (Hidi & Renninger, 2006; Schiefele, 2001; Krapp, 2002). However, with a shift in focus from causation to a concurring relationship, interest and motivation have been supported to often coincide (Ainley & Ainley, 2011; Renninger, 2009). Meaning, instead of examining when or if interest leads to motivation (or vice versa), it may be more effective to explore how stimulating and supporting both in an environment can influence the learner and the learning experience. In an application of this shift in exploration, interest is treated as a factor of intrinsic motivation, the highest internalized form of motivation in Deci and Ryan's (1985) Self-determination theory (SDT) motivation spectrum. According to SDT, motivation is not a singular state but a fluctuation between levels with three general motivational levels: amotivation, extrinsic motivation, and intrinsic motivation (Figure 1.1).

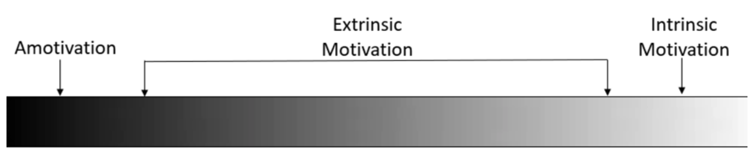

Figure 1.1. Adapted Self-Determination Theory Motivation Spectrum (Deci & Ryan, 2000)

As defined by Deci and Ryan (2004) in the "Handbook of self-determination research", amotivation is the complete lack of any motivation, while extrinsic motivation is motivation determined by external rewards. Extrinsic motivation has four progressive sublevels that differ in the causes and factors contributing to the motivation but none of the sublevels are completely internalized like intrinsic motivation. Intrinsic motivation comes from the individual being motivated by purely internal factors like enjoyment or interest. External factors can play a role regardless of where an individual's motivation falls. This lends opportunities for adjustability since the external environment is easier to manipulate (Carver & Scheier, 1990; Deci & Moller, 2005; Kumar et. al., 2002). The strength and persistence of one's motivation is connected to the level of internalized motive, often referred to as "intrinsic motivation" (Deci & Ryan 2004). Intrinsic motivation is categorized with more positive psychology processes such as enjoyment and interest (Ryan & Deci, 2000). Figure 1.2, adopted from Ryan and Deci (2000), demonstrates the motivation spectrum and connected influencing factors.

Motivation:	**Amotivation**	**Extrinsic (4 progressive levels)**	**Intrinsic**
Regulatory Factors:	**None**	**External; Introjected; Identified; Integrated**	**Intrinsic**
Perceived Cause:	**Impersonal**	**External; Somewhat External; Somewhat Internal; Internal**	**Internal**
Regulatory Process:	**Nonintentional ; Nonvaluing**	**Rewards and Punishment; Ego-Involvement; Personal Importance; Synthesis With Self**	**Interest; Enjoyment**

Figure 1.2. Adapted Table of Self-Determination Theory Motivation Spectrum and Related Factors (Ryan & Deci, 2000)

When evaluating intrinsic motivational factors, one key component is an individual's interest. Individual interest is the most inward and innate level of a person's interest. Understanding individual interest aids in explaining the connection between interest as a possible form or manifestation of intrinsic motivation. According to SDT, three key factors must be present if interest and intrinsic motivation are to be cultivated together (Ryan & Deci, 2000; Reeve, 2006). The three required factors are autonomy, competence, and relatedness (Ryan & Deci, 2000; Reeve, 2006). In other words, an individual must feel that an activity or a topic is useful or has the means of influencing their lives (relatedness), that they have the ability to be successful in performing or learning it (competence), and still maintain a sense of control or choice (autonomy). If these factors are supported in the environment then intrinsic motivation and interest are more likely to be cultivated or increased (Renninger 2009; Deci & Moller, 2005; Kumar et. al., 2002).

1.3.2 *Interest*

Interest is not a singular state but has also been described as consisting of distinctive developmental stages (Hidi & Renninger, 2006). Hidi and Renninger (2006) developed and described a four-phase model for the growth and the progression of interest. The first phase is described as "triggering situational interest" where the audience's attention and initial engagement takes place. If this interaction can be sustained, the first phase may transition into the more stable situational interest, meaning the audience is willing to stay engaged longer without the continuous recapturing of their interest. With further support, situation interest can progress into an emerging individual interest (the third phase). Lastly, the fourth phase is developed when interest becomes innate to the individual, which is the most consistent and stable of all the phases. Within this model, triggering situational interest is the quickest and simplest step to initiate in students. (Hidi & Renninger, 2006). Triggering situational interest is common and well-used in educational settings, even if the technical terms are not always identified (Ormrod & Jones, 2015, pp.196). Situational interest can come from a wide variety of experiences, which can be connected across the motivation spectrum or multiple motives at once (Carmen, 2001; Hayenga & Corpus, 2010). If factors like autonomy, competence, and relatedness are supported through out the experiences, situational interest has the potential to grow into individual interest (Guthrie et al., 2005; Hidi & Harackiewicz, 2000; Ryan & Deci, 2000). Supporting autonomy, competence, and relatedness provides support for the development of intrinsic motivation, even if the initial triggering experience may have had an extrinsic motive (Ormrod & Jones, 2015, pp.194-195). Intrinsic motivation and individual interest are highly correlated with academic success, goal accomplishment, and increased happiness (Hidi & Harackiewicz, 2000; Ryan & Deci, 2000; Reeve, 2006; Hofer 2010; Cacioppo et al., 1994). Situational interest is crucially important in planting the seed for the potential growth of these more stable and long-term states of motivation and interest (Alexander et al., 1994; Durik & Harackiewicz, 2007; Hidi & Renninger, 2006; Reed et al., 2004).

1.4 Target Audience: Upper Elementary Education

The target audience must first be made aware and provided some knowledge of a topic before sustainable interest or motivation can take root (Alexander et al., 1994; Garner & Gillingham, 1991; Hidi & Renninger, 2006). Therefore, by providing content about the egg industry in an environment that can trigger situational interest while supporting intrinsic motivation factors, there is a great opportunity to increase the audience's agricultural literacy and interest in the egg industry. Though this concept has been supported by research for numerous age groups and life stages; upper elementary students (3rd to 5th grade) offer a unique potential (Kovar & Ball, 2013). In the modern-day United States educational system, standardized tests are utilized heavily to measure student ability and growth across multiple disciplines, influence school ranking, and funding (Every Student Succeeds Act [ESSA], 2015; Ormrod & Jones, 2015, pp.394). In the state of Indiana, upper elementary students (3rd to 5th graders) will take over five standardized formative assessments in the 2019-2020 school year (Indiana Department of Education [IDOE], 2019). In 2019, Indiana had only 37.1% of 3rd through 8th grade students pass the "ILEARN" assessment, with only 45 out of over 17,000 participating schools seeing any increase from the previous year (Fittes, 2019). Science, technology, engineering, and math (STEM) education can improve standardized test scores by providing required academic content while students gain problem solving, critical thinking skills that are transferable across disciplines. (Ormrod and Jones, 2015, p.395; Reeve, 2015; The White House, 2010). Additionally, integrating STEM skills within an agricultural context, enables students to learn real-world application and improve the skills applicable to standardized assessments (Stripling & Roberts, 2013, 2014).

Beyond improving scores, numerous studies support a link between early STEM educational interventions and student motivation towards future STEM related opportunities (Wang & Eccles, 2013). Integrating STEM academic content within an agricultural context prepares students for ever-growing workforce opportunities and equips them with the ability to thrive in our global economy and society (Altbach & Knight, 2007; Roberts et al., 2016; Wang & Knobloch, 2018). Upper elementary students do not always innately see these benefits, with research supporting an overall dip in motivation towards academics around 3-5th grade (Potvin & Hasni, 2014; Ormrod & Jones, 2015, pp.210). Therefore, triggering interest and supporting a motivational environment is crucial when implementing agricultural-STEM educational programs (Deci & Moller, 2005; Krapp, 2002; Phipps et al., 2008, pp.230-231; Schiefele, 2001).

1.5 Framework for Agriculture in Education

As the population increases and technologies evolve, generations are further removed from food production and education techniques, and the need for appropriate resources to increase agricultural literacy continuous to grow (Brandt, 2016; Leising et al., 1998; NRC, 1988; Phipps et al., 2008, pp.46-47). In 2009, Roberts and Ball published a theoretical framework for agriculture to be a content and context to foster learning in integrated curricula. Their research emphasizes the importance of increasing agricultural literacy to increase skilled workforce and "literate contributors in a democratic society" (Roberts & Ball, 2009). Figure 1.3, adapted from Roberts and Ball publication (2009), highlights the key importance of integrated curricula which is often the goal of developing previously mentioned agricultural literacy programs.

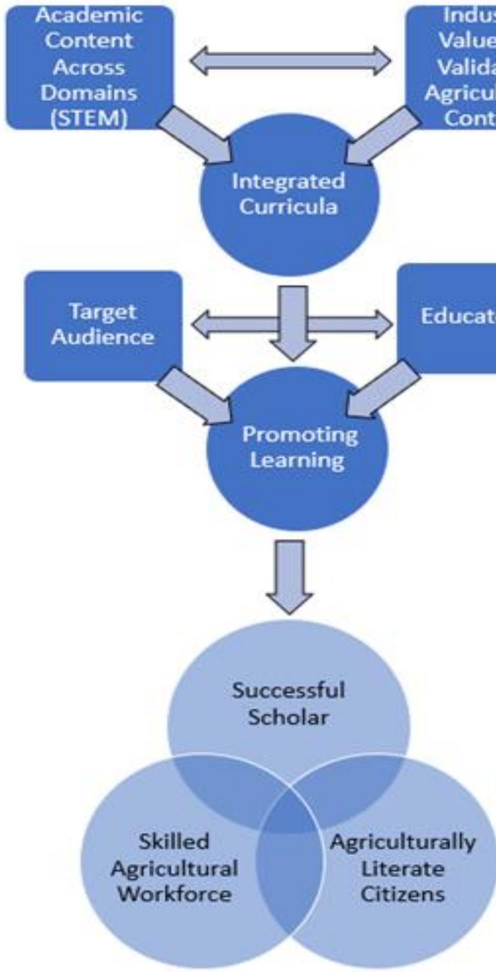

Figure 1.3. Using Integrated Agriculture in Education to Influence Agricultural Literacy (Roberts & Ball, 2009)

1.6 Program Educational Tool

1.6.1 *Online Components*

There are multiple avenues to develop integrated curriculum programs. An increasingly popular format for instructional media is online modules and simulations (Grenoble, 2009; Phipps et al., 2008, pp.292-294; Kumi-Yeboah, et al., 2017). These online components allow for increased consistency across learning environments while reaching a geographically broader audience (Grenoble, 2009). Online learning has been implemented throughout the United States K-12 education settings and provides a viable learning environment with proper development (Chin et al., 2014; Piccian & Seaman, 2007). One theoretical framework used to develop online learning tools is the ARCS model, first published by John Keller in 1987. The ARCS model, based in a learning motivation theory, aids in developing positive student interaction within the online environment. Research has consistently supported the model's emphasis on developing the audience's attention, relevance, confidence, and satisfaction (ARCS) when engaging online to improve academic success (Allen et. al., 2018; Izmirli & Sahin-Izmirli, 2015). As new information and tasks are presented to learners, their attention must be captured, relevance of the material should also be related to the learner, and proper support should be supplemented to maintain learners' confidence in their ability to learn or perform the new information successfully. This additionally leads the learner to feel satisfied when they successfully navigate through the online environment (Keller & Suzuki, 2004). These factors also help trigger situational interest when grabbing the learner's attention and support an intrinsic learning environment by supporting themes connected to SDT such as relatedness, competence, and autonomy. Previous research provides evidence that SDT has successfully supported a K-12 online learning experience using the ARCS model (Chin et al., 2014; Erickson et al., 2019; Shi et al., 2014).

1.6.2 *Interactive Notebooks*

It is crucial that the audience has an opportunity to practice applying the content beyond the online environment. One way to accomplish this is through an interactive notebook (Full Option Science System [FOSS], 2008). Research has supported interactive notebooks as self-regulating learning tools which allow learners to generate and communicate connections from the educational materials. (Al-Baushi, 2015). Interactive notebooks are used throughout the educational system, successfully improving learning outcomes for audiences from kindergarten to adulthood (Klentschy, 2008). The notebook is interactive by prompting its audience to reflect, design, record, or interpret information that is connected to their current learning environment (Aschblacher & 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). The previously discussed traits of an interactive notebook help promote its utility as a STEM instruction resource within an elementary educational setting. Often the nature of successful STEM instructional strategies are often based in learner-centered approaches, lending STEM resources, like an interactive notebook, to be beneficial to agricultural-STEM curriculum (Knobloch, n.d.).

1.6.3 *Team Project*

Collaboration can foster critical thinking and problem-solving skills, which are crucial to STEM success and useful skills outside of academia (Johnson et al., 2006; Reeve, 2015; Yuen et al., 2014). However, merely grouping students and assigning them a common goal does not equal "collaboration" or a successful learning environment (Emmer & Gerwels, 2002; The Teaching Center, 2020). A key factor in productive collaboration is that members understand their personal and others' responsibility in reaching a clear objective (Ormrod & Jones, 2015, pp.210; The POGIL© Project, 2017). One way to do this is by assigning roles or have students self-select roles which outline the specific responsibility of members and overall goals (The POGIL© Project, 2017). The Process Oriented Guided Inquiry Learning (POGIL©) Method of allocating roles, allows students to have clear objectives, personal responsibility, and a supportive environment for creative ideas and solutions to be tested (The Teaching Center, 2020). The POGIL© method has been linked to helping promote academic achievement while supporting critical thinking skills and a problem-solving learning environment (DeGale & Boisselle, 2015; Irwanto et. al., 2018). Additionally, providing an opportunity for self and team post-project evaluations is beneficial when implementing team projects because they can promote a sense of autonomy and accountability while maintaining low social stress (Blumenfeld et al, 2006; Girard et al.,2015; Shi et al., 2014). 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 in a group setting (Ormrod & Jones, 2015, pp. 261).

1.7 Elementary Program: Developing Agricultural Literacy and Interest

In summary, achievement gaps in students meeting academic STEM standards along with low agricultural literacy rates provide educators an opportunity to improve both by implementing an integrated agricultural-STEM curriculum (Kovar & Ball, 2013; Reeve, 2015). In order improve agricultural and STEM literacy effectively, it is imperative to understand how to trigger student interest and maintain motivation during the learning experience (Deci & Ryan, 2004; Hidi &

Harackiewicz, 2000). There are multiple educational tools, such as online learning, interactive notebooks, and collaboration projects, which can be used to employ integrated curricula within an elementary school setting (Grenoble, 2009; Science Scope, 2003; Shi et al., 2014). By applying the ARCS model and SDT while developing am integrated agriculture and STEM curriculum, students can be successful academically, increase agricultural literacy, and become aware and possibly more interested in opportunities in agricultural industries (Erickson et al., 2019; Roberts & Balls, 2009; Wang & Eccles, 2013).

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CHAPTER 2. AN INTEGRATED STEM AND POULTRY SCIENCE CURRICULUM TO INCREASE AGRICULTURAL LITERACY

2.1 Abstract

The shortage of graduates pursuing careers in the poultry industry is linked to low awareness and interest. Increasing agricultural literacy in students could promote engagement in future poultry science opportunities. We created an integrated STEM curriculum within a poultry science context with the objective of assessing students' agricultural literacy development from prior to during and after program implementation. The Elementary Education Gain Grow (E.G.G.) program consists of five online modules, an interactive notebook, a simulation game, and a team project. In fall 2019, 480 Indiana 4th and 5th grade students (13 teachers, 19 classes) enrolled in the pilot program. A 14-question poultry content-based questionnaire was administered online to all students at the beginning of the program, immediately following completion of the online modules, and again at the end of the program. The student content scores (n=111; 23.13% response rate) increased from 7.99 (SD=1.85) pre-program to 9.76 (SD=2.44) after online modules ($p <$ 0.0001). The post-program content scores, completed after the team project, were statistically comparable to the post-module scores (10.05 vs. 9.76). The student notebook responses (n=172; 35.83% response rate) provided qualitative data of their agricultural literacy. Content scores support the program's ability to increase student agricultural literacy via the online modules and maintain agricultural literacy throughout students' application of content during team projects. The notebook responses revealed patterns that showed increase in student agricultural literacy relating to the program's learning objectives. The teacher feedback (n=9; 69.2% response rate) suggest that teachers agreed with the program's effectiveness and that each of the components benefitted students. Our pilot program findings support that an integrated STEM and poultry science elementary curriculum has the potential to increase student agricultural literacy.

2.2 Introduction

Population growth increases the demand for animal protein, especially from poultry meat and egg production (FAO, 2017). In the last 20 years, per capita egg consumption in the United States has increased over 16% (United Egg Producers [UEP], 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 (AFNR) annual job openings are estimated to be around 57,900 but only 61% are expected to be filled by college graduates with expertise in these areas (Goecker et. al., 2015). While the population and food demand grow, inevitable urbanization continues to distance consumers from food production (American Farm Bureau Foundation for Agriculture [AFBFA], 2012).

Though a large percentage of consumers are removed from agricultural practices, their demands are driving legislative changes to increase national production of cage-free eggs by 2025 (Toffel & Sice, 2010; Ochs et al., 2019). Professionals within the egg industry agree that the switch to cage-free egg production will require three to five times more labor, which will contribute to the egg industry's workforce shortage (O'Keefe, 2018). Limited awareness of the egg industry impacts consumer demand and also public interest and perception of future career opportunities. By promoting awareness and knowledge of egg production practices, there is potential to increase the general public's understanding of the poultry industry and overall agricultural literacy.

2.3 Conceptual Framework

In the context of the egg industry, agricultural literacy includes understanding the uses and roles of animals, animal welfare and husbandry practices, production practices' effects on prices, the importance of processing, food safety, and product development and technology (Frick et al., 1991). Therefore, 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 & Leising, 2014). Spielmaker and Leising (2014), along with The National Center for Agricultural Literacy, identified five agricultural sector themes that formed The National Agricultural Literacy Outcomes (NALOs). These themes have learning outcomes that target K-12 students and can be used to assess student agricultural literacy and assist in aligning content to other academic domains. To impact agricultural literacy, it is crucial to have learning outcomes in mind but also to have a framework in order to successfully implement the outcome within an educational environment. Roberts and Ball (2009) published a theoretical framework exploring how agriculture had previously been integrated into formal education as content or a context to foster learning a curriculum. Their final framework proposed implementing agriculture as both content, supported by industry, and a context, for real life examples for other academic domains. By using agriculture as a context, instructors can foster real-world application and improve academic success in students; while using agriculture as a content can help promote agriculturally literate consumers and a trained worker force.

In the modern-day United States educational system, standardized tests are utilized to measure student ability and growth across multiple disciplines, and can influence school ranking and funding (Every Student Succeeds Act [ESSA], 2015; Ormrod & Jones, 2015, pp.394). In 2019, Indiana had only 37.1% of 3rd through 8th grade students pass the "ILEARN" state assessment, with only 45 out of over 17,000 participating schools seeing any increase from the previous year (Fittes, 2019). Science, technology, engineering, and math (STEM) education can improve standardized test scores by providing required academic content while students gain problem solving and critical thinking skills that are transferable across disciplines (The White House, 2010; Ormrod & Jones, 2015, pp.395; Reeve, 2015). Additionally, integrating STEM skills enables students to learn real-world application and improve the skills applicable to standardized assessments (Thoron & Myers, 2012; Stripling & Roberts, 2013, 2014). Some elementary teachers find value in integrating agriculture as a context to traditional STEM academics (Knobloch et al., 2007). However, there is limited research on the success of implementing an agricultural-STEM integrated program to improve agricultural literacy (Wang & Knobloch, 2018).

2.4 Purpose and Objectives

The purpose of our study was to develop an implementable integrated STEM curriculum that increases student agricultural literacy around the egg industry. The Elementary Educate Gain Grow (E.G.G.) program presented the egg industry as a context and content, in order to achieve this objective while meeting required standards for teachers. The following objectives guided our research:

1) Evaluate changes in content scores prior, during, and after the Elementary E.G.G. program

2) Explore patterns of student self-reported gained agricultural literacy via coding of interactive notebook responses

3) Collect teacher feedback on the Elementary E.G.G. program's instructional design and effectiveness

2.5 Methods and Procedures

2.5.1 *Population and Participants*

Recruitment efforts consisted of emailing out 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 13, 2019 was met. Enrollment closed on time with 480 students across 19 classrooms, an average of 24 students (SD = 5.40) per classroom, which were distributed across 8 different Indiana school districts. Data from 10 classrooms, with an average of 15 (SD = 7.94) valid student responses per classroom, were deemed usable for analysis because these classrooms had students who correctly completed all forms of assessment.

After enrolling in the Elementary E.G.G. program, teachers participated in an in-person 30-minute 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.

2.5.2 *Program Development*

When developing the Elementary E.G.G. program it was crucial that academic standards of the pilot's target population were considered. 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 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 increasing agricultural literacy. Integrating STEM academics and agriculture prepares students for ever-growing workforce opportunities, equip them with the ability to thrive in our global economy and society, and improve achievement across disciplines (Altbach & Knight, 2007; Roberts et al., 2016; Wang & Knobloch, 2018). In order to have a uniform assessment of agricultural literacy, NALOs were utilized (Spielmaker & Leising, 2013). These national agricultural literacy learning outcomes have a similar structure to Indiana's academic standards, which are encouraged to be 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 NALO's and Indiana academic standards. We additionally 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 (Table A.1).

The Elementary E.G.G. program curriculum was developed to be implemented in two components that together created a ten consecutive day unit with 45 minutes of student engagement per day. The first part (days 1 to 5) consisted of five online modules which included an embedded simulation game and supplemental interactive notebook. The second portion (days 6 to 10) encompassed a team project which had students apply previously introduced outcomes and skills. The program's content was reviewed by the program's Advisory Panel which consisted of two industry professionals and two unenrolled current Indiana 4^{th} grade teachers.

Online Modules

An online setting was selected because it allowed more students to be reached in a consistent manner. The program's five online modules focused on various aspects of the egg industry in order to expose students to multiple sectors of the egg industry. Module content and interactive features were externalized on Storyline 360 (Articulate, New York, NY). Students were challenged to apply STEM skills and concepts during their exposure to the egg industry. Table 2.1 provides the module's main topic and each module's objectives.

Table 2.1. Overview of online module topics and learning objections

Module	Topic Title	Learning Objectives:
1	Introduction: The Table Egg Industry	• Explain basic the egg industry history (Nationally, Midwest, and within Indiana) • Identify basic life stages of hens in modern day laying hen industry
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
3	Laying Hens: Anatomy & 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
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"
5	Dietary Benefits: Why Eat Eggs?	• Identify components needed for a diet to be balanced • Compare and contrast human and hen nutritional needs • Describe nutritional benefits of a table egg (all types)

John Keller's ARCS model, a learning motivation theory, was used as the framework for formatting and student interaction with the online environments (Keller, 1987). Student motivation is heightened by utilizing ARCS's four crucial factors: Attention, Relevance, Confidence, and Satisfaction. For example, visuals and supplemental audio helped capture students' attention while the real-world context and age appropriate examples aimed to increase content relevance. Students always received feedback and encouragement as they navigated tasks to support their confidence and all tasks had a goal and stated reward aligned with completion to promote student satisfaction upon completion. Research supports that students can succeed academically, experience increased agricultural literacy, and become aware and possibly interested in opportunities in agricultural industries through the ARCS model in a developed agricultural STEM curriculum (Erickson et al., 2019; Roberts & Balls, 2009). Table 2.2 outlines specific features within the five modules that were aligned to the ARCS model to capture student attention and support their continued engagement.

Table 2.2. Overview of module sample features aligned to ARCS model in chronological order

Module	Section	Sample Feature
1	Navigation Tutorial	Interactive text & character dialog
	History of the Hen	Interactive diagrams
2	Steps in Production	Drag and drop activity
	Egg Labeling	Interactive text
3	Digestive System Simulation	Interactive text & character dialog & animation
	Traits in Chickens	Interactive text & interactive diagrams
4	Animal Welfare	Interactive text
	Fulfilling the Five Freedoms	Drag & drop activity
5	Needed Nutrition	Interactive charts
	Parts of the Egg	Interactive diagrams

Simulation Game

Additionally, a simulation game was developed using the ARCS model along with inquiry-based instruction to align with module learning objectives. The simulation game facilitated students' exploration of a hen's digestive system to learn about organs and how proper nutrition is needed in order for hens to lay eggs. Table 2.3 outlines example features within one environment, the hen's gizzard, of the simulation and how each feature is aligned to the ARCS model.

Table 2.3. Simulation game environment (i.e. gizzard) sample features aligned to the ARCS model

Environment	Feature	ARCS Alignment
Gizzard	Interactive animations	Attention
	Character navigation	Attention
	Interactive text	Relevance
	Character dialog	Confidence
	Unlock level activity	Satisfaction

To incorporate inquiry-based instruction, students were posed with questions that required them to investigate the online environment and interact with developed simulation characters in order to complete their “mission” which was representative of the learning objectives. To begin their mission, students selected a representative “feed character” which they then navigated through a hen’s digestive tract while noting observations aligned with the objectives in order to unlock the next organ (Figure A.1).

Interactive Notebook

Applying skills beyond an online environment is crucial for the target audience to have an opportunity to deepen connection to content. One avenue to accomplish this is through interactive notebooks, which have been used to developed to promote learner-centered teaching strategies (Knobloch, n.d., slide 14). The use of notebooks is linked to improved 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 (Aschblacher & 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 notebook that was aligned specifically to prompts and tasks within the online modules. Before each module there was a predictions page with five 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 five prompts to facilitate students’ reflection and connecting with their learning experience. These prediction and conclusion pages were used as an assessment of students’ agricultural literacy and interest developed when engaging online while minimizing performance stress on students.

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 (Johnson, Johnson, & Smith, 2006; Reeve, 2015; Yuen et al., 2014). The Process Oriented Guided Inquiry Learning (POGIL©) method was designed to support inquiry-based collaborative learning experiences developed by Next Generation Science Standards with additional alignment to Indiana’s Science and

Engineering Practices (SEPs) academic learning outcome (POGIL©, 2019). By applying this method to assign student team roles, the Elementary E.G.G. program established an environment for productive collaboration where students had 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. 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.

We instructed teachers to implement the team project right after the online modules (day 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 encapsulated within the online modules. There were three phases teams progressed through to reach the main goal: 1) decisions (day 6 to 7); 2) construction (day 8 to 9); and 3) presentation (day 10). Each phase had corresponding worksheets. First, teams completed their decision packet which allowed them to decide how many hens they would include in the project, the type of laying hen housing facility, calculate hen welfare scores, costs, and income. All team members had to be in agreeance and teams could revise up to three times before advancing to the construction phase. For construction of their laying hen facility, each team was provided a set amount of materials and asked to record at least three elements of the diorama to be discussed during the team presentation. During the project's final phase, presentation, teams filled out the presentation sheet and followed the directions to present their project to the class and instructor. They were also provided a self and peer evaluation form.

2.5.3 *Study Design*

The Elementary E.G.G. program used mixed methods to collect data to evaluate the program's impact on student agricultural literacy, both quantitatively and qualitatively, and teacher experience. We evaluated impact on student agricultural literacy throughout the program in addition to collecting teacher feedback over program effectiveness after program implementation. Assessments involving student agricultural literacy were approved by the program's Advisory Panel while the teacher feedback survey was reviewed by six unenrolled Indiana teachers. All protocols and assessments were approved by Purdue University's Institutional Review Board prior to any program implementation. Response rates for data collection varied since notebook pages could only be matched to a classroom, not an individual student, and was dependent on the number of correctly completed responses that were available for analysis.

Instrumentation

To collect quantitative data pertaining to student agricultural literacy, three online content assessments were created in alignment with online module objectives (Table A.2). The content assessments had a total of 14 multiple choice or true and false questions that were given in the same format for each assessment. All poultry science-based content questions were approved by the program's Advisory Panel, consisting of two poultry science professionals and two Indiana 4th grade teachers, prior to administration. These assessments were completed by students at three time points throughout the program: immediately before starting online modules (pre-program), immediately after completion of the online modules (post-modules) and before starting the team project, and immediately following completion of the team project (post-program). Students were unaware of personal content scores and all assessments were administered online using Qualtrics (Qualtrics, Provo, UT).

Qualitative data from student notebook pages were coded to gain insight on student agricultural literacy patterns relating to modules. Upon completing each module, students were asked to reflect on what they learned in each module through one to three open-ended prompts. Enrolled teachers manually mailed or electronically scanned or faxed in the student notebook pages in order to return responses to researchers by post program completion. Student responses were manually compiled in Excel® for electronic organizational storage (Microsoft® Office Excel®, 2016).

Teacher feedback was solicited by administering an online questionnaire via Qualtrics (Qualtrics, Provo, UT). The questionnaire consisted of ten agreement scale questions (Range 0-100; 0 = disagree; 100 = agree) and three open-ended questions. The ten agreement scale questions focused on the program's implementability, benefit to students, and value as an integrated STEM curriculum and are outlined in Table 2.6. The questionnaire was reviewed by a panel (n=6) of current Indiana teachers who were not enrolled in the program and then appropriate suggested adjustments were made by researchers before sending the questionnaire to all enrolled teachers (n=19) in January of 2020. Teacher open ended responses were compiled into Excel® for electronic organizational storage (Microsoft® Office Excel®, 2016).

Quantitative Analysis

All quantitative responses were analyzed using IBM SPSS software (Version 26; Armonk, NY). Only data that were collected correctly and completely across all assessments from students and corresponding classrooms were used for analysis. An ANOVA post hoc Tukey's test compared pre-program, post-module, and post-program content scores. ANOVAs were used to assess classroom effect, with teacher as a nested variable, on content scores. Additionally, an ANOVA compared teacher agreement across program feedback responses.

Qualitative Analysis

Qualitative data from student notebooks and teacher responses were analyzed following the inductive qualitative data coding method (Feldman, 2018, pp.188-190). To support our qualitative content analysis, we implemented a previously validated checklist developed in 2014 to insure proper analysis throughout the preparation, organization, and reporting phase (Elo et. al., 2014). In this manner, useable responses from student notebook conclusion pages from selected predetermined prompts, one per module, that inquired about the students' agricultural literacy in relation to each module were collected. Then responses were 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 three 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 (Table 2.7).

2.6 Results

2.6.1 *Quantitative Agricultural Literacy Results*

Objective 1: Evaluate changes in content scores prior to, during, and after the Elementary E.G.G. program. The pre-program, post-module, and post-program assessments were scored based on the number of correct answers out of the 14 questions. An ANOVA post hoc Tukey's test was used to compare means of each assessment's content scores of students' (n=111) who correctly and completely answered all three assessments (Table 2.4). The number of questions answered correctly significantly increased from the pre-program to post-module assessments (7.99 vs. 9.76; $p < 0.0001$). However, there was only a slight numerical increase with no significance from post-module to post-program (9.76 vs. 10.05), supporting that students learned the majority of content from online modules and were able to retain content knowledge throughout the five-day team project.

Table 2.4. ANOVA post hoc Tukey's test comparison of pre-program assessment, post-module assessment, post-program assessment student content scores (content scores were out of a possible 14 points). Subscripts indicate statistical differences between content score means. (n=111; 23.13% response rate; *p* < 0.0001)

	Mean ± SE
Pre-program	$7.99^{a} \pm 0.30$
Post-module	$9.76^{b} \pm 0.30$
Content post-program	$10.05^{b} \pm 0.30$

An ANOVA was conducted to explore the effect of classroom on student content knowledge with teacher encompassed within classroom since all but one teacher had only one classroom. Classrooms (n=10; 52.63% response rate) that had complete and correct data for all three content assessments were used in the analysis. Classroom had a significant effect ($p = 0.008$) on student content scores (n=111; 23.13% response rate) suggesting differences in the classroom environments did influence the program's impact on student agricultural literacy.

2.6.2 *Qualitative Agricultural Literacy Results*

Objective 2: Explore patterns of student self-reported gained agricultural literacy via coding of interactive notebook responses. By inductively coding student qualitative notebook responses we developed patterns of students' self-reported agricultural literacy gains across modules (Table 2.5). Student responses were in reference to prompts that targeted students communicating what they learned from each module and at the end of the entire program. Notebook pages could only be matched to a classroom and not an individual student; therefore, if a classroom (n=10; 52.63% response rate) had correct and complete responses for content score, qualitative student responses from that classroom were analyzed if the written responses were also complete and correct (n=172; 35.83% response rate). Patterns of students' agricultural literacy from their responses (Table 2.5) often reflected the module's learning objectives (Table 2.1), meaning that students self-reported learning concepts that were outlined by the researchers as the module's learning objective. This indicates that students comprehended the main topics within each module. However, topics such as anatomy and animal welfare appeared multiple times, supporting that students may have retained more knowledge about these topics.

Table 2.5. Coded agricultural literacy patterns from student interactive notebook responses (n=172; 35.83% response rate)

Module	Prompt	Pattern	Example
1	*"In this module, three things that I learned were…"*	Industry scope Life stages History	*"Midwest most eggs cause most access to corn and soybean"* *"life cycle of a chicken"* *"brought by ships over 500 years ago"*
2	*"From this module the two things I learned the most about were…"*	Housing systems Processing	*"what cages they stay in and what they do in each different cage"* *"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 Comparing eggs	*"digestive parts of the hen"* *"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 a[n] egg is called albumen"*
Overall	*"The most important information that I learned in this program was…"*	Animal welfare Hen anatomy	*"That chickens have five freedoms and their welfare is important to produce eggs"* *"How the egg comes out of the chicken"*

2.6.3 *Qualitative and Quantitative Teacher Feedback*

***Objective 3: Collect teacher feedback on 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. There was no significant difference between agreement levels when comparing across statements (Table 2.6). This indicates that on average, teacher agreement level did not vary among prompts.

Table 2.6. ANOVA of teacher agreement (n=9, 69.2% response rate) to program statements in relation to usability, curriculum value, and student benefit (Scale range 0-100; 0 = disagree; 100 = agree)

Statement	**Mean Agreement Score (Min; Max)**	**df**	**P-value**
I would recommend others to enroll in the program.	77.11 (40;100)	9	0.937
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)		

However, individual teachers (n=9) did have different agreement means to prompts when providing feedback about their experiences ($p<0.0001$). Though majority of teachers (n=6) reported high individual agreement to statements (scores above 75), two were identified with low agreement (below 75 but above 50) and one teacher 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. When displeasure or frustration was mentioned the causes or suggestive improvements were inconsistent between teachers and often vague in description (Table 2.7).

Table 2.7. Teacher feedback in relation to prompts (n = 9; 69.23% response rate)

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	78%
"What are three words/phrases you would use to describe students' experience when engaging with the program?"	1) Interesting 2) Challenging 3) Online Issues	1) 67% 2) 44% 3) 33%
"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%

Inductive qualitative data coding indicated that teachers agreed that each of the components supported learning and overall majority of descriptions were positive when reflecting on student program experience. However, there was limited agreement on possible improvements, indicating that each teacher and teacher experience 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 towards the team project component. Additionally, one teacher suggested more online components could aid in supporting a wider range of students' abilities while a third voiced that their frustration was connected to online issues.

2.7 Conclusion

The egg industry is experiencing a shortage of competent graduates entering the workforce. Increasing agricultural literacy in students could promote future engagement in poultry science opportunities because students now have better understanding and awareness of the industry. Being exposed to the scope of possible opportunities within the egg industry is an important step in order to develop and support interest in students, along with promoting students becoming educated consumers. Results from our pilot Elementary E.G.G. program suggest that the participating student's knowledge of poultry science increased after engaging in the STEM-integrated curriculum. This demonstrates the value and need for more integrated curriculum in order to continue improving student agricultural literacy. Additionally, the majority of teachers reported positive experiences supporting that the program was effectively implemented in their classrooms.

Content scores from pre-program compared to post-module or post-program assessments support that student agricultural literacy increased with program implementation. However, there was only a slight increase from post-module to post-program, supporting that students learned the majority of content during online modules and retained content knowledge throughout the team project. A study utilizing an integrated STEM and poultry science curriculum reported that online modules could improve high school students' knowledge of poultry science (Erickson et al., 2019). Results from the Erickson et al. (2019) study suggest that additional engagement, beyond the online resources, may enhance the overall student learning experience. Based on this, our study added a team project to provide students with a hands-on, real-world scenario 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 & 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 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 experience (Klentschy, 2008; Science Scope, 2003). In our program, students completed prediction and conclusion reflection pages along with completing prompts during navigating the online environment that related directly to the modules. 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 comprehensive ability and academic standards (Spielmaker & 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 modules' 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 & Harackiewicz, 2000; Hofer 2010; Reeve, 2006; Ryan & Deci, 2000). Students might recall agricultural literacy 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, but it does support that 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 score. Previous exploratory research by Wang and Eccles (2013) supports that a students' learning environment can predict student engagement and academic motivation. Furthermore, students' engagement and motivation to further interact with the academic content was found to have an association to academic achievement (Wang & 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 educational environmental factors including teacher or peer interactions along with physical attributes of each classroom that can have impact on student learning. These factors can 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). Again, this provides evidence for why agricultural literacy scores differed across classrooms within our program.

The majority of 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 & Martin, 2002a, 2002b; Humphrey, 1994; Trexler & Suvedi, 1998;). 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 & Edwards, 2012). However, some teachers 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 & Dyer, 2007). Individual teachers' highest ranked concerns were much less homogeneous than the potential benefits provided by the same teachers (Bellah & Dyer, 2007). These findings suggest concurrency with our teacher feedback trends. Our sample teachers were able to uniformly identify what they agreed with or had positive experiences with, but when frustrations were voiced there was little consistency.

2.7.1 *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. Therefore, the notebook responses from classrooms that had students within the 23.13% were also used for analysis if they too were completed correctly. 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 unawareness of content scores aimed to enhance the validity due to lower achievement anxiety (Cassady, 2004). Lastly, multiple modes of data collection and less than 25% response rates lead to some restriction when transferring findings outside of the piloted sample groups 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 (60%) and lower on web-based (43%) (Fraze et al., 2004). 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., 2004). In the future, a bi-model 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., 2004; Phillips, 2016).

2.8 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.

2.9 Summary

The Elementary E.G.G. program improved student agricultural literacy and was viewed as an effective program by the majority of teachers. Findings demonstrate the educational value and need for more STEM-integrated curriculums in order to increase 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, 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.

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CHAPTER 3. INCREASING STUDENT INTEREST IN POULTRY SCIENCE THROUGH AN INTEGRATED STEM PROGRAM

3.1 Abstract

The demand for egg and poultry proteins is continuously increasing while the rising need for egg industry professionals is not being met. College graduates express relatively low interest in poultry science careers with the primary reasons including lack of exposure and low general knowledge of the industry. By integrating poultry science concepts into elementary education, required academic STEM standards are given a real-world context, improving the learning experience and providing an opportunity to stimulate student interest in the egg industry. The Elementary Education Gain Grow (E.G.G.) program was developed as an integrated STEM curriculum with five online modules, a supplemental interactive notebook, an embedded simulation game, and a team project. The program was piloted in the Fall of 2019 in nineteen 4th and 5th grade classrooms across eight Indiana districts. A pre-program questionnaire assessed student individual interest scores while post-module and post-program assessments evaluated students' situational interest in relation to engaging with the online modules or the team project. Student situational interest (n=111; 23.1% response rate) was elevated when engaging in both the online modules and the team project with all scores above a neutral two out of a possible four. A paired t-test indicated that subscales assessing levels of attention, challenge, novelty, and overall scores were significantly higher in the team project ($p < 0.05$). Qualitative data from student notebook responses (n=172; 35.83% response rate) was collected and inductively coded for student interest themes related to each module and the overall program. Student interest themes reflected modules' learning objectives with students demonstrating repeated interest in egg and hen anatomy along with animal welfare. Overall, the pilot Elementary E.G.G program curriculum successfully impacted student situational interest while engaging in activities within the context of the egg industry. Future implementation is needed to understand the program adoptability nationally and to improve accessibility for the target audience.

3.2 Introduction

As the global population increases, the demand for animal protein from poultry and eggs continues to grow. In the last 20 years, egg consumption per capita has increase over 16% within the United States (United Egg Producers [UEP], 2019). The Midwestern U.S. states, Indiana, Iowa, Ohio, and Michigan, are within the top seven egg producing states, with Indiana ranked 3rd nationally (USDA NASS, 2019). Nationally, egg production and total number of commercial laying hens grew 3% between 2017 and 2018 (UEP, 2019). However, there are not enough skilled professionals interested in entering the egg industry workforce to meet the growing employment demands at either the state or national level. Annual job openings in the United States Agriculture, Food, and Natural Resources (AFNR) are estimated at 57,900, with only 61% expected to be filled by college graduates with aligned field expertise (Goecker et. al., 2015). Poultry science professionals are needed in a variety of sectors such as disease management, sales, nutrition, processing, equipment, and marketing services (Jacob, 2019; Texas A&M University, 2020). Consumer demands are driving legislative changes to increase production of cage-free eggs and by 2026 the USDA's Agricultural Marketing Service predicts that 64% of eggs will be produced cage-free compared to the 17.8% produced cage free in 2020 (Toffel and Sice, 2010; USDA NASS, 2019). The transition to cage-free egg production will require three to five times more labor and will create an even greater deficit of qualified workers in the industry (O'Keefe, 2018).

Although consumers can drive animal production changes, there is often a disconnect between production practices and the public's understanding of these practices (Ochs et al., 2019). This lack of awareness and knowledge contributes to the low interest in possible poultry science careers (Lent et al., 1994). A person's agricultural literacy level is used to describe their ability to communicate and analyze basic information about agriculture at a conversational level based on their awareness and knowledge (Frick et al., 1991). One way to increase agricultural literacy is to embed agriculture content as a context in our public education classrooms (Roberts and Ball, 2009; Spielmaker and Leising, 2014). Integrating science, technology, engineering, and mathematics (STEM) required academic content with agriculture can equip students with transferable critical thinking skills and create opportunity to increase that audience's agricultural literacy and interest in the egg industry (Altbach and Knight, 2007; Roberts et al., 2016; Wang and Knobloch, 2018). This increase of academic skills is especially crucial in Indiana classrooms, with less than half of students in third to eighth grade passing state standardized tests in 2019 (Fittes, 2019). In order to increase academic performance and possible future involvement in the egg industry, it is crucial to foster students' interest and support their motivation during the agricultural and STEM integrated learning experience.

One theory that has been used to increase student motivation and influence their interest is self-determination theory (SDT), developed by Deci and Ryan (1985). The SDT framework focuses on creating learning experiences that can support the development of student relatedness, competence, and autonomy (Deci and Ryan, 2004). In other words, an individual must feel that an activity or topic is useful or has the means of influencing their lives (relatedness), that they have the ability to be successful in performing or learning it (competence), and still maintain a sense of control or choice (autonomy). Research supports the successfulness of implementing these SDT supportive factors within an online environment to improve student motivation and interest (Chen and Jang, 2010; Shi et. al., 2014; Erickson et al., 2019). Like motivation, interest is not a singular state but has been described as distinctive four developmental stages beginning with triggering situational interest and completes with sustained individual interest (Hidi and Renninger, 2006). Triggering situational interest is the quickest and simplest step to initiate within a person (Hidi and Renninger, 2006). Situational interest is crucially important in planting the seed for the potential growth of more stable and long-term states of motivation and interest which can influence future decisions (Reed et al., 2004; Hidi and Renninger, 2006; Durik and Harackiewicz, 2007). Therefore, by supporting SDT and triggering situational interest during the integrated-STEM learning experience, students' interest within poultry sciences has the potential to take root.

3.3 Materials and Methods

The first step of our study was to create an implementable STEM curriculum that fosters and supports students' interest in poultry science. Our specific objective was to evaluate changes in student interest during engagement in the developed poultry science contextualized STEM curriculum. We hypothesized that engagement in the program would stimulate student situational interest. The Elementary Educate Gain Grow (E.G.G.) program brings awareness to poultry science by using the egg industry as real-world examples for science, technology, engineering, and math (STEM) and supporting student interest and motivation during program engagement. By increasing student exposure to the egg industry, the program provided opportunities to increase student situational interest while maintaining required STEM learning objectives.

3.3.1 Participants

Recruitment efforts consisted of emailing an information flyer with a webinar link over appropriate listservs, emailing Indiana elementary and intermediate school principals publicly available on the Indiana Department of Education website), and presenting the enrollment opportunity at a summer teacher workshop. The pilot Elementary E.G.G program was open to any Indiana 4th or 5th grade teacher who responded before we reached our predetermined 500 student maximum during the summer of 2019. Teachers were selected on a first come basis and the program closed enrollment July 2019 with 480 students and 13 teachers across 8 different Indiana school districts. Interest data from students was deemed usable for analysis if responses were completely and correctly filled in across the related assessments. After enrolling in the Elementary E.G.G. program, teachers participated in an in-person 30-minute facilitator training that provided all teacher and student materials. The trainer provided a program overview, outlined requested materials for research purposes, online navigation training, and ended with an open question segment.

3.3.2 Instructional Design

Program Learning Outcomes

When developing the Elementary E.G.G. program, it was crucial that academic standards be embedded within the curriculum to allow teachers and students to meet academic standard requirements within a real-world context. In order to have a uniformed measurement of agricultural literacy, the National Agricultural Literacy Outcomes (NALOs) were created (Spielmaker and Leising, 2013). These learning outcomes have the same structure as many states' academic standards, which are the foundation for developing curricula within each state. Therefore, the Elementary E.G.G. program's learning outcomes were aligned with both NALOs, Indiana standards, and STEM outcomes to create an implementable curriculum for Indiana upper 4th and 5th grade classrooms.

Online Modules

The first component of the Elementary E.G.G. program was five online modules focused on different components of the egg industry with the developed content delivered via *Storyline 360* (Articulate, New York, NY) and was completed by students in days 1-5 of the ten-day program. Table 3.1 describes module topics and program objectives.

Table 3.1: Elementary E.G.G. module topics and aligned objectives

Module	Title	Learning Objectives
1	Introduction: The Table Egg Industry	• Explain basic egg industry history (Nationally, Midwest, and within Indiana) • Identify basic life stages of hens in modern day laying hen industry
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
3	Laying Hens: Anatomy & 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
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"
5	Dietary Benefits: Why Eat Eggs?	• Identify components needed for a diet to be balanced • Compare and contrast human and hen nutritional needs • Describe nutritional benefits of a table egg (all types)

An online setting was the initial interaction and main distributor of content because it allowed more students to be reached in a consistent manner. John Keller's ARCS model, a learning motivation theory, was used as the framework for formatting and student interaction with the online environment (Keller, 1987). Student motivation is heightened by utilizing ARCS's four crucial components: attention, relevance, confidence, and satisfaction. As new information and prompts are presented to students, age appropriate examples formed connections to content while encouragement and praise for accomplishments helped support ARCS components within the online environment. The ARCS model helps support SDT factors of relevance, competence, and autonomy while students are engaging in an online setting (Chin et al., 2014; Erickson et al., 2019).

Simulation Game

Additionally, a simulation game was developed using the ARCS model to align with Module 3 (Laying Hens: Anatomy and Physiology). Students were posed with questions and then through exploring new environments and interacting with other characters, they ascertained the concepts. For instance, students selected a representative "feed character" that allowed them to travel through a hen's digestive tract to learn about each organ's purpose and how proper nutrients are needed in order to produce a high-quality egg. Figure 1 includes screen shots of the interaction the student's "feed character" navigated to complete the mission of providing the hen with nutrients to lay an egg.

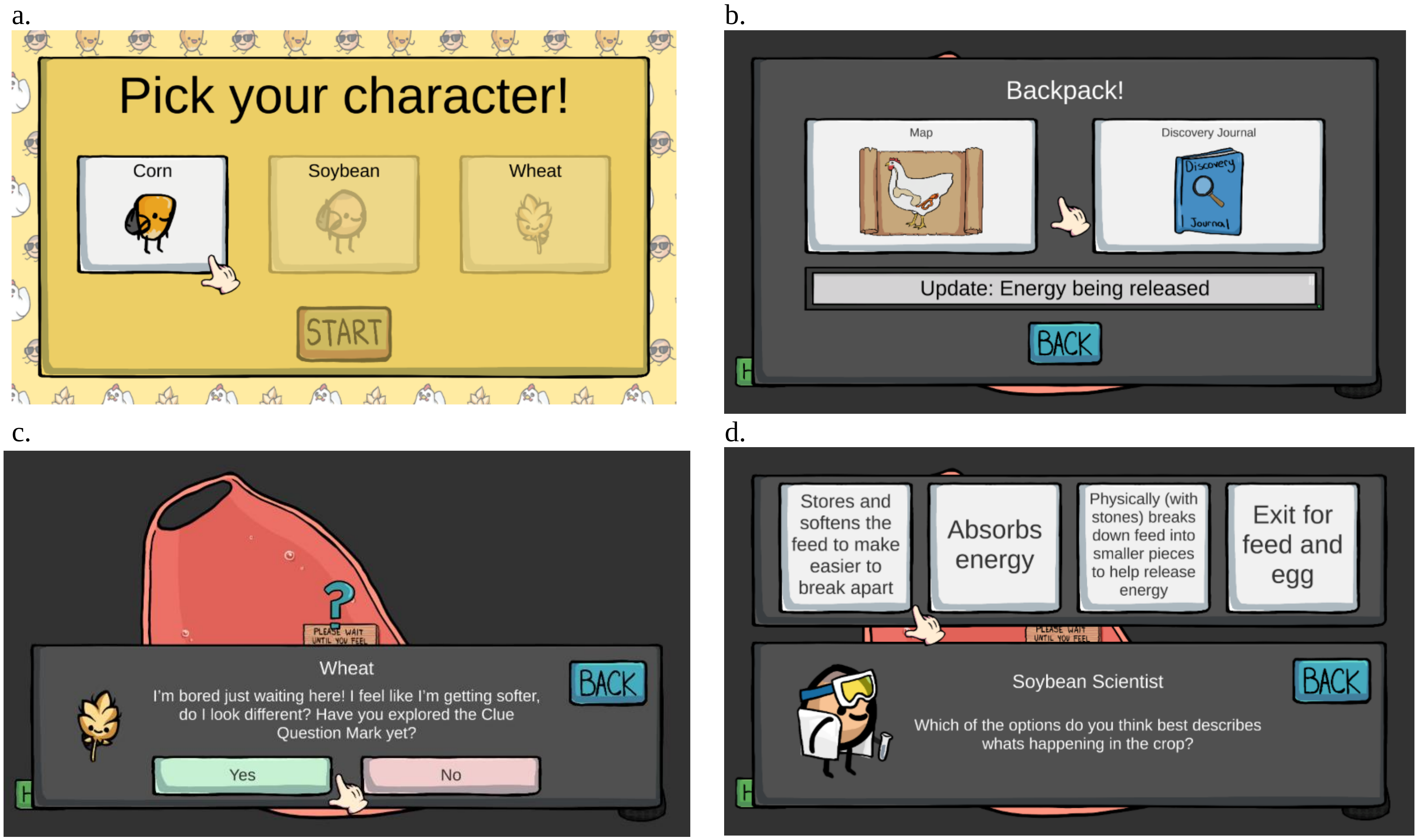

Figure 3.1. Simulation game screenshots of feed character selection (a); backpack options (b), inside crop (c); and interaction with "soybean scientist" (d).

Interactive Notebook

Interactive notebooks provide crucial opportunity to practice applying learned skills beyond an online environment. They are interactive by prompting the user to reflect, design, record, or interpret information that is connected to the current learning environment (Science Scope, 2003; Aschblacher and Alonzo, 2011). Specifically, for elementary students, the interactive notebooks allow learners to connect more meaningfully with the content and practice communicating their internal learning experience (Science Scope, 2003; Klentschy, 2008). In this way, the notebook can be used as an assessment of student interaction or interest when engaging online while minimizing performance stress on students. In the Elementary E.G.G. program, each enrolled student received an interactive notebook that was aligned with the online module's activities and prompts. Before each module, a prediction page helped gauge student interest and agricultural literacy while a conclusion page helped student reflect and build connections to their learning experience. Additionally, a final reflection page was embedded into the notebook to prompt reflection and connection to the entire program experience.

Team Project

The team project was completed immediately following the completion of the online modules (days 6-10). The purpose of the team project was to allow students to apply the information learned in the online modules in a STEM-based poultry industry project. Collaboration can foster critical thinking and problem-solving skills, which are crucial to STEM success and useful skills in future careers (Johnson et al., 2016; Yuen et. al., 2014; Reeve, 2015). By applying The Process Oriented Guided Inquiry Learning (POGIL) method to allocate team roles, students have clear objectives, personal responsibility, and a supportive environment for productive collaboration (The POGIL© Project, 2019). 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 in a group setting (Ormrod and Jones, 2015, p.210). Providing teachers with POGIL roles and grouping guidelines also aids in maintaining some level of comparability of team experiences by providing uniform procedures and objectives across classrooms. Teachers were instructed to form teams of 3 to 4 student and assign each student to one of the following roles: recorder, checker, manager, or technician. Program implementation procedures called for teams to be equal in ability strength and likelihood of success.

The project was designed with three developmental phases and prompted decisions that challenged teams to reach the end goal. The project created an authentic learning experience for the users by tasking teams to create a laying hen facility that was economically sustainable while maintaining a high animal welfare. Teams progressed through decisions, construction, and presentations. During the decision phase, teams determined their ideal laying facility by deciding how many hens and housing type which would influence welfare scores, costs, and possible income. In the construction phase, each team was provided a set amount of materials and had to record at least three elements of their diorama to be pointed out during the team presentation. Teams filled out their presentation worksheet and then presented their design. In total, the decision and construction phase were each two days of 45 minutes of engagement with presentations being on the final day of the program, having the team project taking a total of five days.

3.3.3 Study Design

To evaluate the pilot implementation of the Elementary E.G.G. program, a mixed methods approach was used to collect and analyze data to assess the program's impact on student situational interest in regard to the program's components and the egg industry. All protocols and assessments were approved by Purdue University's Institutional Review Board. The program was designed to be utilized for 30 to 45 minutes each day for a consecutive 10-day period. After the completion of the facilitator in-person training conducted by researchers, teachers were required to implement the program between September and December 2019.

Quantitative Data

Before starting the online modules, students completed the "pre-program" assessment, which included five individual interest questions that were pre-validated and assessed using a 5-point Likert smiley-face scale validated for elementary students (Linnenbrink-Grarcia et al., 2010; Hall et al., 2016). The scale was validated for the target population by administering to a population of 36 Indiana 4th graders not enrolled in the program. Responses maintained the previously validated Cronbach's alpha (.728) which validated the use of the scales as an assessment in our study.

Immediately following the completion of the online modules, students were administered a questionnaire (post-module) that measured situational interest. This assessment included previously validated situational interest questions designed for elementary school students that assessed student situational interest during their online or team project experience (Sun et al., 2008). Each of the 15 situational interest question had four levels of interest students could select to describe the related activity. Then five subscales, three questions within each subscale, are used to assess the influence of the five factors (1: amount of attention required; 2: activities challenge level; 3: level of exploration; 4: level of enjoyment during the activity; and 5: the novelty of the activity) on the students' overall situational interest when engaging in that activity.

The final questionnaire (post-program) was administered immediately following the completion of the team project. This questionnaire was identical to post-module but differed by the referencing of the team project as the activity being assessed. Since unique phases of interest (individual interest vs. situational interest) require different assessments there were no direct comparison or correlation made between them (Hidi and Renninger, 2006). Only responses (n=111; 23.1% response rate) from students who correctly and completely took all questionnaires were used for analysis and program evaluation. All questionnaires were administered online through Qualtrics. (Qualtrics, Provo, UT).

Qualitative Data

Additional information on student interest was collected by having teachers return student notebook prediction, conclusion, and final reflection pages (11 pages total), at the completion of the program. Each page had a prompt in relation to student interest during a certain module or the entire program (final reflection page). Prompts on pages directly targeted assessing students' interest by asking students to reflect and then record what they found most interesting in modules or what areas they wanted to explore in more depth. Student responses from 10 classrooms (52.63% response rate), were deemed usable for analysis since these classrooms had students who correctly completed all interest questionnaires and qualitative data could only be aligned to classrooms not individual students. Student responses (n=172; 35.83% response rate) were manually compiled in Excel® for organizational storage while themes were then inductively coded to highlight common student interest themes per module (Microsoft® Office Excel®, 2016).

3.3.4 Statistical Analysis

All quantitative responses were analyzed using IBM SPSS Version 26 with consultation from Purdue University Department of Statistics statistical consulting services. Internal consistency of scales was assessed through Cronbach's alphas, and once confirmed, an ANOVA post hoc Tukey's test compared the five subscales related the situational interest during the online modules or the team project. Then a paired t-tests were conducted to compare situational interest level of each subscale across the online modules and the team project. ANOVAs were used to assess classroom effect, with individual teachers included within classroom since all but one of teacher had one classroom. Significance was declared at $P < 0.05$.

Qualitative data were analyzed following the inductive qualitative data coding method (Feldman, 2018, p.188-190). To support our qualitative content analysis, we implemented a previously validated checklist developed in 2014 to insure proper analysis throughout the preparation, organization, and reporting phase (Elo et al., 2014). In this manner, useable responses from student notebook conclusion pages were coded to develop themes from selected predetermined prompts, one per module, that inquired about the students' interest in relation to each module. Then responses were analyzed to explore what impact the program had of student interest based on the coded themes.

3.4 Results

3.4.1 Individual Interest

Before starting the program, student individual interest scores were assessed (n=111) and then compared across classrooms. Individual interest questions maintained an appropriate Cronbach's alpha ($\alpha = 0.751$) supporting their validity and a mean score of 3.57 (± 0.10), which is slightly above a neutral three out of a possible five. Because the sample of students who completed the program did have some initial interest in the egg industry, their situational interest might have had a higher likelihood of being stimulated compared to samples with of a neutral or negative individual interest score.

An ANOVA found no significant difference in individual interest scores when compared across classrooms ($P = 0.06$; n = 10; 52.63% response rate). Thus, all students across the 10 classrooms started the program with similar individual interest.

Different scales were used to assess individual and situational interest, since each are designed to evaluate different phases of interest (Hidi and Renninger, 2006). Consequently, there cannot be any direct comparison between individual interest and student situational interest. Therefore, all individual interest results can only be used to help describe students prior to their program experience.

3.4.2 Situational Interest: Online Modules

Students first engaged with the program's online modules with the embedded simulation game and supplemental notebook (days 1 to 5 of program). Situational interest was assessed immediately following completion of the online modules (Table 3.2). All factors related to situational interest (i.e. attention, challenge, exploration, enjoyment, and novelty) raised situational interest since all were rated above a two on a four-level interest rating. Novelty was significantly the lowest ($p< 0.0001$) and therefore had the least impact on student situational interest. The enjoyment factor was numerically highest followed by exploration, indicating the amount of exploration required in the online environment and enjoyment from engaging with the modules had the most influences on student situational interest. These results connect the use of the ARCS model to online module development by successfully supporting students' corresponding SDT needs. Respectively attention factor impact followed behind exploration and was slightly numerically higher than challenge.). This indicates that though students' attention was needed and students were challenged these two factors were not as numerically as impactful.

Table 3.2. Internal consistency and ANOVA post hoc Tukey's test results of situational interest for 4th and 5th grade students immediately following completion of the online modules. Subscripts indicate which means are significantly different with significant declared at $p < 0.05$. (n=111; 23.1% response rate)

	Attention	Challenge	Exploration	Enjoyment	Novelty	Total	*P*-value
Cronbach's Alpha	0.677	0.745	0.782	0.781	0.613	0.866	
Mean ± SE	3.07^{a} ± 0.05	3.08^{a} ± 0.05	3.23^{a} ± 0.05	3.24^{a} ± 0.05	2.74^{b} ± 0.05	3.07 ± 0.05	< 0.0001

3.4.3 Situational Interest: Team Project

Students engaged in the team project during days 6 to 10 of program. Student team project situational interest scores demonstrated that students' interest was stimulated across all subscales since all average scores were above a two out of a potential four (Table 3.3). Again attention, challenge, exploration and enjoyment factors had significantly higher levels compared to novelty ($p < 0.001$). However, numerically attention was rated the highest followed by challenge, suggesting that the amount of attention demanded during the team project and the challenge level were the most important factors in increasing situational interest during the team project. This is not surprising since the project did require team collaboration and multiple steps with heavily integrated STEM concepts that could have demanded students to pay more attention and increased the project's challenge level. Yet, STEM collaborative projects are not a novel educational instructional strategy (Yuen et al., 2014). Therefore, though this was a pilot team project, the novelty factor of a STEM team project did not as heavily impact student situational interest.

Table 3.3. Internal consistency and ANOVA post hoc Tukey's test results of situational interest for 4th and 5th grade students immediately following completion of a collaborative team project. Subscripts indicate which means are significantly different with significance declared at $p < 0.05$. (n=111; 23.1%response rate)

	Attention	Challenge	Exploration	Enjoyment	Novelty	Total	*P*-value
Cronbach's alpha	0.684	0.716	0.815	0.770	0.772	0.922	
Mean	3.42^{a} ± 0.09	3.31^{a} ± 0.06	3.28^{a} ± 0.06	3.30^{a} ± 0.06	2.95^{b} ± 0.06	3.25 ± 0.06	< 0.001

3.4.4 Situational Interest: Online VS. Team Project

Students expressed higher situational interest related to the team project compared with the online modules. Attention, challenge, novelty, and total situational interest scores were significantly greater for the team project compared with online learning (Table 3.4). This suggests that students' situational interest was more stimulated when engaging in the team project because of the increased attention demand, challenge level, and novelty of the project compared to the online modules. This could suggest that a team project might innately be more successful at increasing the sample students' interest because the instructional design required higher levels of the three previously mentioned factors while maintaining comparable levels of exploration and enjoyment.

Table 3.4. Paired t-test comparing situational interest (means and standard error) of the online modules and the team project for 4th and 5th grade students (n=111; 23.1% response rate). Subscripts indicate which means are significantly different with significance declared at $p < 0.05$.

Subscale	Online	Project	*df*	*P*-value
Attention	$3.07^{b} \pm 0.04$	$3.42^{a} \pm 0.05$	110	<.0001
Challenge	$3.08^{b} \pm 0.06$	$3.31^{a} \pm 0.05$		<.0001
Exploration	$3.23^{a} \pm 0.05$	$3.28^{a} \pm 0.06$		0.40
Enjoyment	$3.24^{a} \pm 0.05$	$3.30^{a} \pm 0.06$		0.34
Novelty	$2.74^{b} \pm 0.05$	$2.95^{a} \pm 0.06$		<0.01
Total	$3.07^{b} \pm 0.04$	$3.25^{a} \pm 0.05$		<.0001

Student situational interest differed across classrooms for both the online modules and team project (n = 111; p <0.0001). This suggests that the environment of each classroom, such as teacher or peers, did have an effect on students' situational interest when engaging with both activities. Every learning environment will inevitably have differences, even when implementing the same curriculum. This is because of the undeniable impact of social interactions, which are unique across any educational setting and can influence student psychological states like interest (Ormrod and Jones, 2015, p.322-324). Therefore, though both the online modules and the team project were able to stimulate situational interest in students with team project having a statistically higher average total score, it is unsurprising that there were differences in the extent of situational interest stimulation across classrooms.

3.4.5 Notebook Interest Themes

Inductive qualitative data coding of student interactive notebook responses (n=172; 35.83% response rate) resulted in the development of interest themes relating to the modules and the overall Elementary E.G.G. program. The coded themes connected to each module, along with a notebook prompt, and examples of responses that were coded into that theme were organized in Table 3.5. Based on the coded themes, student interest was related to the modules' main objectives when engaging with that particular module and a few themes, hen anatomy and animal welfare, appeared across multiple modules. Student engagement relating to the objectives were developed through the ARCS model, which aims to capture and maintain student motivation and interest (Keller, 1987). Themes of interest revolving around these objectives support that the ARCS model can successfully impact student interest in an integrated STEM poultry science curriculum. Additionally, anatomy of the hen and animal welfare were predominant themes that appeared in the majority of responses across two or more modules (i.e. hen anatomy in modules 1, 3, and overall; animal welfare in modules 4 and overall). This indicated that these two topics were particularly of interest to our students.

Table 3.5. Student interest themes in relation to the online modules and overall program (n=172; 35.83% response rate)

Module	Prompt	Theme	Examples
1	*"I want to learn about…"*	Hen anatomy	*"how eggs are made"*
2	*"If I were to investigate more about eggs, my focus would be on…"*	Processing	*"getting the eggs clean"*
3	*"I was the most curious about…"*	Hen anatomy	*"I want to learn more about the organs in the chicken body"*
4	*"After this module I want to research more about…"*	Animal welfare	*"what type of cage they need to feel safe"*
5	*"If I could tell my friends and family one thing about eggs it would be…"*	Comparing eggs	*"the ones you can eat look different on the inside from the ones that hatch into chicks"*
Overall	*"I still want to know more about…"*	Hen anatomy Housing systems Animal welfare	*"how chicks are made in a hen"* *"the coops and how their different"* *"what do chickens do in there [their] free time"*

3.5 Discussion

The increasing gap between the egg industry workforce demand and the lack of trained graduates entering into the industry could be mitigated by increasing students' interest. Our primary objective was to create and evaluate an implementable STEM and poultry science curriculum that fosters and supports interest in elementary school students. Overall, student situational interest was stimulated during the online modules and team project and student self-reported interest themes collected from student notebook responses exhibited the learning objectives of each module.

Students enrolled in the E.G.G. program had slightly above neutral individual interest in the egg industry at the start of the program. There were no differences in individual interest across classrooms before program implementation. However, our study measured situational interest as the primary indicator of interest across the program because developing the internalized form of individual interest was outside of our program's scope (Hidi and Renninger, 2006; Harackiewicz et al., 2016). However, because our sample students did have initially higher individual interest, they might have been more susceptible to our programs attempts to stimulate situational interest (Hidi and Renninger, 2006). One study revealed that Elementary students were aware that many food products were produced by animals, but did not understand the scope of how the food was produced (Meischen and Trexler, 2003). Previous awareness that much of their food comes from animals may indicate why students in our study had some level of prior interest in the poultry industry. Hess and Trexler (2011) found that the lack of sub-concepts of agriculture prevented their audience's ability to develop schemas needed to improve agricultural literacy, which supports that our students' higher initial individual interest could have helped amplified the benefits our program. To conclude, though our sample students' individual interest was higher than neutral, all levels were comparable across classrooms; therefore, we connote that all classrooms had the same potential for success.

Many factors of the learning environment, from social interactions to instructional strategies, have been reported to influence student interest (Ormrod and Jones, 2015, p.324). Situational interest may develop from a wide variety of experiences, making it an ideal target for curriculum programing since the external environment factors, like classroom activities, are easier to manipulate (Deci and Moller, 2005; Hayenga and Corpus, 2010). Additionally, when properly sustained and supported, situational interest can eventually lead to the development of individual interest (Hidi and Renninger, 2006; Harackiewicz et al., 2016). Our program targeted situational interest through student engagement in online modules and a collaborative team project. The ARCS model was used as the framework in the development of the online modules. By using this framework, we were able to develop positive student interaction within the online environment (Keller, 1987). This positive interaction may lead to feelings of satisfaction as students successfully navigate through the online environment (Keller, 1987; Keller and Suzuki, 2004). This may explain why the online modules as an instructional strategy supported student attention, relevance, confidence, and satisfaction while participating and successfully activating exploration and enjoyment factors (Keller, 1987; Chin et al., 2014). The novelty of poultry science for many students has been suggested to effectively create situational interest (Palmer, 2009; Hulleman et al., 2010). However, the novelty subscale score for the online modules was found to be the factor with the least stimulation of situational interest. Students in the United States are commonly exposed to online learning technologies and the use of this platform for instructional delivery might have lowered the novelty of the program for students (Kumi-Yeboah et al., 2017).

Additionally, the interactive notebook was utilized as a supplemental resource to the online modules and may have indirectly influenced student situational interest when participating online. 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). Student engagement and motivation to learn academic content is related to individual academic achievement (Cacioppo et al., 1994; Reeve, 2006; Hofer 2010). Increased academic achievement supports development of learner interest (Hofer 2010; Hidi and Harackiewicz, 2000; Ryan and Deci, 2000). Therefore, the interactive notebook and online modules in our program may have worked synergistically together to further develop situational interest.

The team project increased student overall situational interest, attention, challenge, and novelty compared with the online modules. Poultry science concepts are complex and dynamic and the team project was able to stimulate the required attention and challenge level the subject innately brings (Romanelli et al., 2009). Techniques used in our team project, such as the context personalization (i.e. choosing and designing their personal ideal laying hen facility) and hands-on learning (i.e. constructing and presenting their facility), has been shown to increase situational interest (Holstermann et al., 2010; Walkington, 2013). The team project also may have appealed to the targeted audience of upper elementary students because developmentally, students at this stage seek out peer interactions (Ormrod and Jones, 2015, pp.210). Wentzel et al. (2004) found that friendships at this age are crucial to both learning and interest. Therefore, because the team project was developed as a collaborative experience, with the POGIL© method to assign student roles and responsibilities and promote a positive social dynamic, the team project might have been innately more interesting to students because of the positive peer interactions (Ormrod and Jones, 2015, pp.210; Wentzel et al., 2004).

Interest themes from notebook student responses primarily aligned with the objectives of each module. This suggests that the use of the ARCS model when developing the online modules increased student interest in the main concepts. The ARCS model is successful at developing the audience's attention, relevance, confidence, and satisfaction (ARCS) when engaging online (Izmirli and Sahin-Izmirli, 2015; Allen et. al., 2018). When students feel competent in an activity, their motivation and interest often increases (Bandura, 1997). The interactive notebook may have improved student situational interest as previously discussed because of its ability to support student learning. Specifically, a few themes, such as hen anatomy and animal welfare, were of particular interest to students because these themes appeared across multiple modules. The developmental stage of students in our program may strongly influence their interest in animal welfare because at this age students are beginning to master and practice recognizing the needs of others (Ormrod and Jones, 2015, p.210). This ability to recognize needs may be directly related to concern over animal welfare issues and meeting animals' needs and therefore could have increased student interest in exploring animal welfare. Student interest in hen anatomy aligned with the simulation game that was embedded in module 3. Similar to the overall modules, the simulation game was developed using the ARCS model as the framework and incorporated inquiry-based learning strategies. Although overall novelty was relatively low for the online modules, incorporating novelty through the simulation game may have impacted overall student situational interest (Sun et al., 2008).

The classroom environment can impact student situational interest (Hidi, S. and Harackiewicz, J.M.,2000; Wang and Eccles, 2013). Our Elementary E.G.G. program collected usable student data across ten classrooms with nine different teachers. There was an effect of classroom on student situational interest in response to the online modules and team project. Student situational interest is impacted by factors in the learning environment, such as social interactions and instructional strategies (Ormrod and Jones, 2015, p.324). A previous study from our research group observed an effect of teacher on situational interest in high school students completing a STEM-based online poultry science program (Erickson et al., 2019). Differences in the learning environment has the potential to cause variation in student response to implementation of an integrated STEM and agriculture program (Stubbs and Myers, 2015).

3.5.1 Limitations

There were limitations in our study that may have influenced the implementation of the program in the classrooms. Prior to the start of the program, we met in-person with each teacher enrolled in the program and discussed the goals of our project. At this meeting we provided verbal directions as well as a written facilitator guide. Assistance was readily available over phone and email throughout the duration of the program. Despite these directions, response rates, including students that completed all assessments, were low in this study. Additionally, the short-term nature of our program limited the ability to measure sustained interest beyond the program's completion. Our convenience sample was comprised of teachers who self-selected to enroll their classrooms in the program and was limited to a set number of students from school districts within Indiana. Limits in the research design and response rates prevent casual inference of results without further investigation on influence from variation in learning environments.

3.5.2 Future Research

Future longitudinal research is needed to explore how involvement in a STEM integrated poultry science program impacted student involvement in related career opportunities. This pilot study explored the Elementary E.G.G. program's ability to impact situational interest after completion of the online modules and team project. Data from our program has the potential to provide a framework for the development of future integrated STEM programming. Increasing cooperation from teachers and students to promote more complete and correct data collection would drastically aid in improving the response rate and the transferability of future program results.

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CHAPTER 4. CONCLUSION

This thesis examined the Elementary E.G.G. program's impact on student agricultural literacy and situational interest by reporting the results of program implementation. Chapter Two outlines the program's impact on student agricultural literacy and teacher feedback on the program's usability and value as an integrated STEM poultry science curriculum. Chapter Three evaluates the program's impact on student situational interest. The current chapter will discuss conclusions of each previous chapter in relation to the program as a whole.

Results from Chapter Two support an increase in student agricultural literacy after engaging in the Elementary E.G.G. integrated STEM poultry science curriculum. Student content scores (n=111; 23.13%) significantly increased ($p < 0.0001$) from the pre-program assessment (7.99 ± 0.18) to the post-module assessment (9.76 ± 0.23) and were maintained to the post-program assessment (10.05 ± 0.23). Therefore, the program's design and framework could be used to increase agricultural literacy in other poultry science sectors and was deemed to be appropriately matched to the target audience. Online modules were a successful resource to distribute the main learning objectives and engagement in the team project allowed sustainability of student learning gains. Topics related to anatomy and animal welfare were highlighted by students as topics of interest in the interactive notebook. There was a classroom effect on student content knowledge gains. The majority of teachers reported positive experiences; however, individual teacher frustrations were inconsistent. It can be concluded that the program increased the sample students' agricultural literacy even though unique classroom environments had some effect. Furthermore, students' responses to prompts about their increased knowledge during online module engagement supported that students believed they learned the most about anatomy and animal welfare.

Chapter Three evaluates student individual and situational interest. At the start of the program, student (n = 111; 23.13% response rate) self-reported individual interested was 3.57 ± 0.10 (scale: 1 to 5 with 1 having no interest and 5 having the highest level of individual interest). Above neutral individual interest scores may indicate a higher likelihood of having situational interest stimulated. There was a classroom effect on situational interest ($p < 0.0001$). The online modules (3.07 ± 0.04) and team project (3.25 ± 0.05) both successfully stimulated overall situational interest (being on a scale of 1 to 4 with 1 representing no stimulation of situational interest and 4 representing the highest level of situational interest). All situational interest subscale scores (i.e. attention, challenge, exploration, enjoyment, and novelty) across the online modules and the team project had a mean above a two out of the four-point Likert scale. Previous validation of this situational interest assessment interprets subscale or total scores above a two to represent that students are experiencing situational interest during the activity in question. Since the program aimed to stimulate student interest, these results indicate that the program's design was effective. Student situational interest was heightened by utilizing ARCS motivational model's four crucial components: attention, relevance, confidence, and satisfaction during the online modules. Situational interest subscale scores support that the online modules captured student interest heavily due to student exploration (3.32 ± 0.05) and enjoyment (3.24 ± 0.05) when engaging online compared to other subscale factors. Students expressed higher situational interest related to the team project (3.25± 0.05) compared with the online modules (3.07 ± 0.04) with significant differences ($p < 0.01$) among three of the five subscales (attention, challenge, and novelty) and their overall total scores. The team project's subscales assessing student's attention (3.42 ± 0.05) and challenge (3.31 ± 0.05) supported that these two factors were the most impactful to the overall team project scores (3.25 ± 0.05) with attention being the highest. Therefore, we conclude that students' situational interest was more stimulated when engaging in the team project partially because of the increased demanded attention and challenge level of the project compared to the online modules. Coded themes from student qualitative responses relating to what interested them the most aligned with the online module's learning objective with repeating interest in anatomy and animal welfare. Overall, the Elementary E.G.G. pilot program stimulated student situational interest.

In conclusion, the Elementary E.G.G. program was able to improve student agricultural literacy, stimulate situational interest, and was perceived by teachers as an effective STEM-based program. There is a great value and need for more STEM agriculture integrated curricula and the Elementary E.G.G. program is an example of successfully applied design and framework principles. Further research is needed to develop additional STEM and agriculture integrated curricula that relate to other age groups and agricultural industry sectors. Additionally, improving data collection methods and compliance to promote higher response rates could help expand future programs to be more adaptable to a wider range of audiences with more transferable findings. Our program was successful in increasing agricultural literacy and supporting student situational interest during student engagement. Finally, teacher responses supported the program's effectiveness as an integrated STEM and poultry science curriculum.

APPENDIX

Table A.1. Alignment of Learning Outcomes (E.G.G., STEM, Indiana, & NALOs)

Program Learning Outcomes:	**STEM Outcomes**	**Indiana Academic Standards**	**NALOs**
1.1) Explain basic the egg industry history (Nationally, Midwest, and within Indiana) **1.2)** Identify basic life stages of hens in modern day laying hen industry	**Math:** Economic impacts of egg industry **Technology:** Industry mechanization and used technologies **Engineering:** Construct and compare plausible solutions	**Earth and Space Science** (4.ESS.4) **Mathematics** (4.DA.1) **Computer Science Resources** (3-5. PA.1) **Physical Science** (4.PS.3) Life Science (4.LS.2) **Social Studies: History** (4.1) **Science and Engineering Process Standards** (SEPS.1,3,6,8)	**Agriculture and the Environment** (T1.3-5a) **Culture, Society, Economy & Geography** (T5.3-5d; T5.3-5f)

2.1) Explain the main steps and locations needed to produce a table egg **2.2)** Describe and differentiate hen housing systems **2.3)** Define the common types of table eggs	**Science:** Scientifically compare the different types of egg production systems **Technology:** Technology used to produce table eggs **Engineering:** Construct and compare plausible solutions	**Language Arts** (4.RN.2.2) **Computer Science Resources** (3-5. PA.1) **Physical Science** (4.PS.3; 4.PS.4) **Science and Engineering Process Standards** (SEPS.1,3,6,)	**Food, Health & Lifestyle** (T3.3-5b) **Science, Technology, Engineering & Mathematics** (T4.3-5b) **Culture, Society, Economy & Geography** (T5.3-5b)
3.1) Identify the basic steps and purpose of the digestive and reproductive system of a laying hen **3.2)** Describe farmer can choose genetic traits **3.3)** Connect how genetics can affect egg production	**Science:** Biological and physiological principles **Math:** Feed needed to produce quality eggs **Engineering:** 3-5. E.2	**Life Science** (4.LS.1-3; 4.LS.2.5; 5.LS.1; 5.LS.3) **Engineering** (3-5. E.2) **Computer Science Resources** (3-5. PA.1) **Earth and Space Science** (5.ESS.2) **Science and Engineering Process Standards** (SEPS.1,3,6,8)	**Science, Technology, Engineering & Mathematics** (T4.3-5c)

4.1) Define animal welfare and identify the "Five Freedoms" **4.2)** Describe the purpose of taking care of laying hens **4.3)** Identify basic ways to make sure laying hens are being cared for with connection to the "Five Freedoms"	**Science:** Scientifically understand the role on animal welfare and how it applies to animals **Engineering:** Construct and compare plausible solutions	**Mathematics** (4.DA.3) **Language Arts** (4.RN.3.1) **Computer Science Resources** (3-5. PA.1) **Earth and Space Science** (4.ESS.4; 5.ESS.3) **Life Science** (4.LS.2; 5.LS.3) **Science and Engineering Process Standards** (SEPS.1,3,6,8)	**Plants and Animals for Food, Fiber, & Energy** (T2.3-5d)
5.1) Identify components needed for a diet to be balanced **5.2)** Compare and contrast human and hen nutritional needs **5.3)** Describe nutritional benefits of a table egg (all types)	**Science:** Role of nutrients for biological benefits/ necessities **Math:** Quantity of nutrients found in table eggs **Engineering**: Construct and compare plausible solutions	**Engineering** (3-5. E.2) **Language Arts** (4.RN.4.1) **Computer Science Resources** (3-5. PA.1) **Physical Science** (4.PS.3) **Science and Engineering Process Standards** (SEPS.1,3,6,8)	**Food, Health, & Lifestyle** (T3.3-5a)

Table A.2. Content assessment questions alignment to online module's learning objective

<table>
<tr><th>Module 1-5 Learning Objectives</th><th>Assessment Questions (correct answer bolded)</th></tr>
<tr><td>1.1) Explain basic the egg industry history (Nationally, Midwest, and within Indiana)

1.2) Identify basic life stages of hens in modern day laying hen industry</td><td>1) True or False: The egg industry has stayed the same throughout history and as little to do with Indiana

2) What stage of life is a hen in if she can produce eggs for us to eat?
a) Hatching
b) Growing
c) Processing
d) Laying</td></tr>
<tr><td>2.1) Explain the main steps and locations needed to produce a table egg

2.2) Describe and differentiate hen housing systems

2.3) Define the common types of table eggs</td><td>3) Which option has the correct order of steps that it take for an egg to be on a kitchen table?
a) Hatchery, Grower, Laying, Processor, Retail
b) Laying, Growing, Hatching, Processor, Retail
c) Laying, Growing, Retail, Hatching, Processor
d) Growing, Processor, Laying, Retail, Hatching

4) What kind of hen housing system is shown below?

a) Aviary
b) Conventional
c) Enriched-Caged
d) Free-Range

5) Which kind of egg is not sold at stores for people to eat?
a) Cage-Free
b) USDA Approved
c) Free-Range
d) Fertilized</td></tr>
</table>

3.1) Identify the basic steps and purpose of the digestive and reproductive system of a laying hen 3.2) Describe farmer can choose genetic traits 3.3) Connect how genetics can affect egg production	6) **True** or False: The digestive tract helps absorb energy from feed that hens use to lay eggs that we can eat. 7) **True** or False: You can predict how a hen may act or how her eggs look based on her parents' genetics. 8) Based on genetics a farmer can select hens that _________. **a) All below** b) Lay larger eggs c) Lay eggs with stronger shell d) Act calmer and more gentle
4.1) Define animal welfare and identify the "Five Freedoms" 4.2) Describe the purpose of taking care of laying hens 4.3) Identify basic ways to make sure laying hens are being cared for with connection to the "Five Freedoms"	9) Animal welfare is ______. a) How much space an animal needs **b) How an animal copes with its environmen**t c) How an animal looks and sounds d) How quickly an animal can be trained 10) **True** or False: A hen's health can change the quality of eggs she lays. 11) How can a farmer provide laying hens with one of the Five Freedoms of animal welfare? a) Make sure the make a lot of sound b) Make sure they come when called **c) Make sure they have food and water** d) Make sure they are around technology
5.1) Identify components needed for a diet to be balanced 5.2) Compare and contrast human and hen nutritional needs 5.3) Describe nutritional benefits of a table egg (all types)	13) Which type of food is an example of carbohydrate (quick energy source) for chickens and humans? a) Salt **b) Corn** c) Water d) Meat 14) True or **False**: Hens and humans do not need protein in their diet. 15) What is the yolk (yellow center) in an egg? a) A chick **b) Protein and fat** c) Water and air d) Left over feed

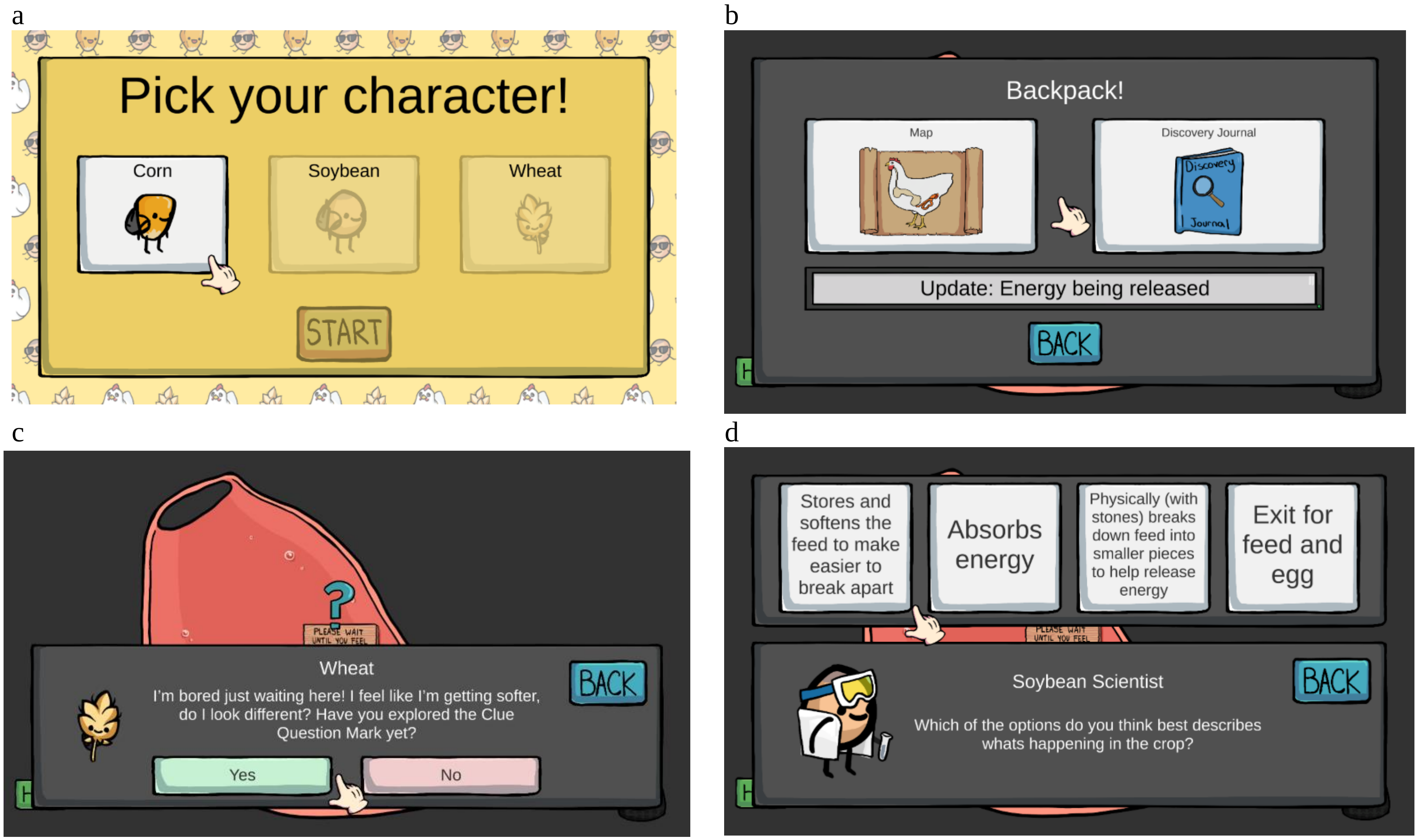

Figure A.1. Simulation game screenshots of feed character selection (a), backpack options (b), inside crop (c), interaction with "soybean scientist" (d)