Poultry in the classroom: effectiveness of an online poultry-science-based education program for high school STEM instruction

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ABSTRACT Public knowledge of the poultry industry is limited, yet attitudes towards the industry shape consumer behavior and influence the attractiveness of poultry careers and future study. This study assessed an online learning program contextualizing STEM learning within poultry science which was designed to increase poultry knowledge and interest. High school student participants (n = 169) across 16 classes (n = 12 teachers) in Indiana completed seven 30-min online modules during the fall 2018 semester. This case study used a mixed-methods, sequential explanatory design. Student knowledge and interest in poultry and teacher perceptions of the program were examined using quantitative measures. The study's qualitative portion assessed perceptions of the learning experience and comprised open-ended student and teacher survey questions and a teacher focus group. Qualitative data suggested that students' poultry knowledge, including awareness of the industry and related careers, was improved following the modules. Paired t-tests showed moderate to large effect sizes regarding increases in content quiz scores following each module ($P < 0.001$, Cohen's d = 0.45 to 0.80). Students' mean interest in poultry was initially low and remained statistically similar upon completion of the program (M = 1.84, 1.87; p = 0.67). Student and teacher statements indicated that design features of the program enhanced interest for some students. Other students did not perceive the program and its poultry science topics to be interesting or relevant to their lives. Results from this study can be used to inform the creation of effective poultry learning resources to contribute to workforce development and enhance the industry's public image.

Key words: online learning, public awareness, interest, education, poultry

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INTRODUCTION

The public's knowledge of the poultry industry is limited (Erian and Phillips, 2017). Yet, awareness of the industry has important connections to both the attitudes of consumers and interest in related careers (Osborne and Dyer, 2000). Little is known about the public's sources of information on the poultry industry. Although reputable resources exist, popular media sources may have more influence on public opinion (Daigle, 2014). In part, public knowledge of the poultry industry may be limited by the lack of coordinated effort to incorporate agriculture in K-12 education (NAE and NRC, 2014). Teachers have few resources for teaching poultry science concepts, which are not standard in K-12 curricula (Barton, 2009). However, educational experiences during the K-12 years contribute to attitudes, beliefs, and identity formation—creating effects that persist through adulthood and inform career choice and behavior as consumers (Messersmith et al., 2008).

To enhance the public's agricultural literacy and support agricultural workforce needs, policy and education reports have suggested integrating agriculture with science, technology, engineering, and mathematics (**STEM**) instruction (NRC, 2014). Agriculture offers a context: making learning STEM concepts more meaningful and relevant to students (Bybee, 2010; Moore, et al., 2014). Integrated STEM-agriculture approaches engage students in learning based in realistic, transdisciplinary problems (Vasquez et al., 2013). There is evidence that integrated STEM-agriculture experiences before college may influence awareness of agriculture and interest in related careers (Ortega, 2011). However, most secondary school teachers have not taught in this manner before and many have no experience with the agriculture topics (Wang et al., 2011). New models of teaching must be developed for successful implementation of integrated STEM-agriculture learning.

The present study assesses the effectiveness of an online educational program for high school students

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Table 1. Overarching themes of online modules created for integrated STEM-poultry instruction in high school classrooms.

Module	Content
1	Introduction to the Table Egg Industry
2	Laying Hen Anatomy, Physiology, and Biology
3	Introduction to Animal Welfare
4	Laying Hen Management
5	Industry Technologies
6	Egg Processing
7	Review

contextualizing STEM learning in poultry science. To enhance student learning and interest in poultry, 7 online modules were created using a variety of educational technologies and grounded in principles of integrated STEM instructional design (Robinson et al., 2018). This integrated STEM-poultry online program is part of a larger initiative addressing poultry workforce pipeline issues by increasing K-12 students' exposure to related educational and career opportunities. The present research was guided by the following objectives: 1) describe students' knowledge and awareness of the poultry industry before, during, and after completing the program and 2) explore students' learning and motivation experiences related to program instructional design.

MATERIALS AND METHODS

Instructional Design

To develop high school students' knowledge, awareness, and interest in poultry science and related careers, seven 30-min online integrated learning modules were created to showcase the laying hen industry. Modules addressed STEM topics within poultry science contexts to meet teacher expectations for alignment with state and national standards related to science, mathematics, and animal science learning (Table 1). Purposeful contextualization of integrated STEM learning was guided by the instructional design framework recently introduced by Robinson et al. (2018). Sample content from one module is summarized in Table 2.

Our objective was to offer students a perspective of the global laying hen industry: its scope, importance, and relevance to their personal lives and goals. Although content represented poultry science broadly, examples within the program were drawn from laying hen producers and processors within Indiana to enhance the ability of students to relate to concepts (Keller, 1987). A panel of poultry experts including industry representatives, faculty, and extension specialists oversaw module development. The panel ensured program content accuracy, face validity, and content validity. Throughout development, the expert panel assisted with revisions to ensure alignment with program aims.

Program design emphasized learner-centered, student-directed learning for 2 reasons: (1) most teachers have relatively little experience or expertise in poultry teaching and (2) learner-centered experiences may support students' interest in the topic and enhance self-regulated learning skills (Deci and Ryan, 1985). As such, learning was predominantly independent and self-paced. However, each 30-min module was designed to fit within a single class period, allowing time for follow-up discussion. Teachers served the role of facilitator, assisting students with accessing and working through the online program and coordinating discussion following module completion.

Table 2. Sample module content in online STEM-poultry learning resources for high school students.

Section	Content	Features
1	Welcome	Text
2	Introduction Video	Video
3	Reproduction Introduction	Text
4	Hen Laying Cycle	Interactive chart
5	External Anatomy	Interactive diagram
6–7	Reproductive Tract Anatomy	Interactive diagram
8	Anatomy of the Egg	Interactive diagram
9–10	Development of the Egg	Interactive text slides
11	Egg Abnormalities	Interactive text slides
12	Factors of Stress in Poultry	Dialog with character
13	Stress Video	Video
14	Your Thoughts	Open-ended response
15	Better Egg Production	Pictures and character dialog
16	Genetics and the Environment	Pictures and character dialog
17	Your Thoughts	Written case study
18	Careers to Consider	Career interview video
19	Your Thoughts	Open-ended response
20	Selective Breeding	Dialog with character
21	A Hen for Each Environment	3D video
22	Improvements in Science	Interactive text slides
23	Test Your Knowledge	Drag and drop activity

Module Topic: Laying Hen Anatomy, Physiology, and Biology.

The program utilized innovative instructional technologies including interactive figures, video, 360-degree video, and simulation games to engage students in poultry science learning (Figure 1). Simulation games were included in 4 of the 7 modules (Figure 2). These games involved students in realistic problem-based scenarios highlighting modern management and facility design technologies. For example, one game posed students with a series of management-related health issues, requiring students to resolve issues by adjusting management and provide written justification for their recommendations using pathology and welfare concepts. The program's scaffolded, encouraging environment was designed to accommodate learners of varying experience and interest (Azevedo and Jacobson, 2007). Adaptive programming offered students enactive mastery experiences to support their learning and competence beliefs (Bautista, 2011). To develop students' awareness and interest in poultry-related careers, videos of interviews with real poultry industry employees were embedded throughout the modules. In these videos, local poultry industry employees offered personal accounts of their career paths, daily job activities, and the meaningfulness of their work. In addition, interviewees offered students perspective on job prospects and requirements—assisting students with advice on navigating the pathway to their career.

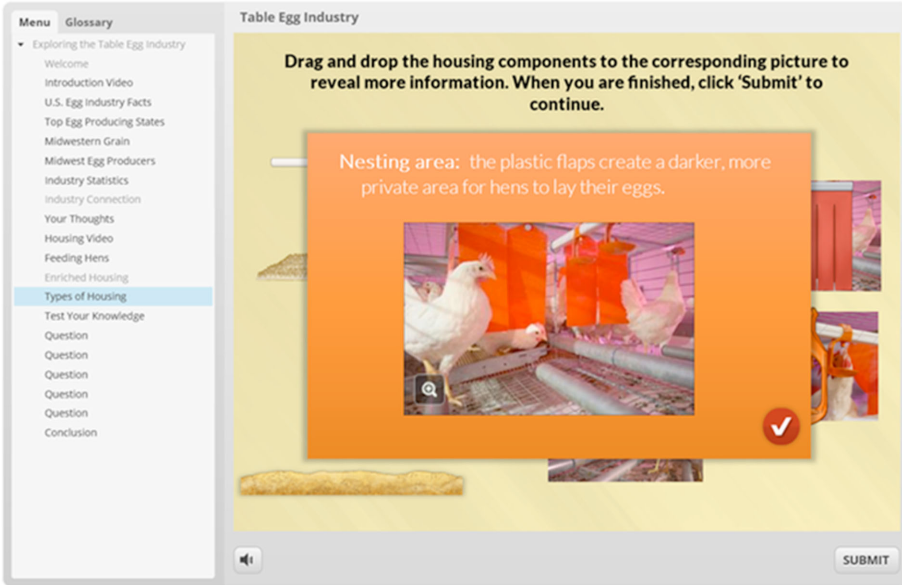

Figure 1. Snapshot of the student-view for a module in the online poultry program.

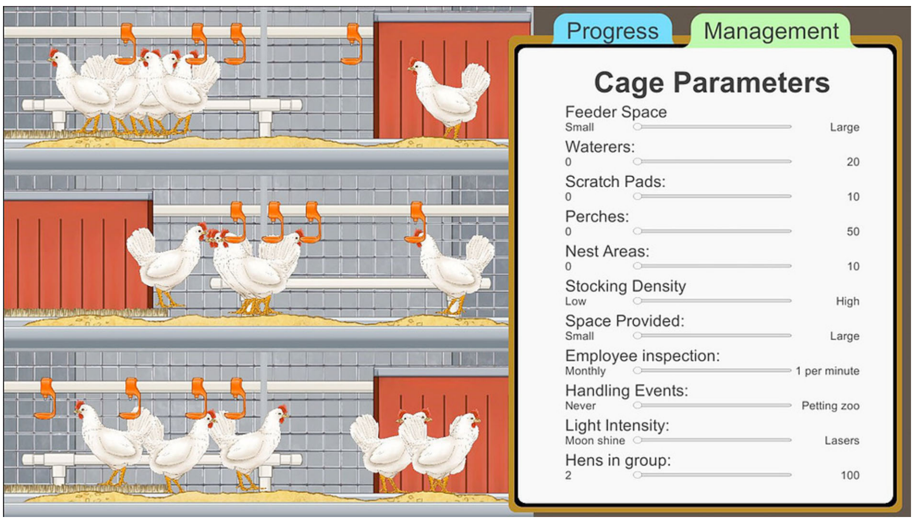

Figure 2. Still of the simulation game within the online poultry program.

Population and Participants

Indiana high school junior- and senior-level agriculture and biology courses served as the pilot population for this study. Middle to late adolescence is marked by fluctuating beliefs, attitudes, and values as young adults define their identities in academic, vocational, and social spheres (Messersmith et al., 2008). School experiences during this time have a major influence on students' future personal, academic, and career choices (Schunk and Meece, 2006). To test the effectiveness of our program with this population, a convenience sample of teachers was recruited through word-of-mouth, social media, and email listservs. We accepted all applicants, placing no limits on the number of enrollees. Program enrollment totaled 16 schools with 499 students in 23 classrooms. Class sizes averaged 21 students but varied substantially ($s = 11.14$). The sample for the study consisted of 169 complete, matched student respondents to the pre- and post-questionnaires (34.1% response rate) from the 18 classes of 12 teachers. Incomplete data and data from participants who did not provide assent or parental consent were excluded. The institutional review board approved all experimental procedures. Demographic information of participants is summarized in Table 3.

Study Design

This case study used a mixed-methods, qualitatively-driven approach and employed a sequential explanatory design (Creswell, 2003; Johnson and Turner, 2003; Yin, 2013). Mixed-method designs take advantage of

Table 3. Demographic information of participants in online STEM-poultry program.

		n	%
Gender	Female	68	40.2
	Male	96	56.8
	Non-binary/not specified	5	3.0
Classification	Freshman	47	27.8
	Sophomore	43	25.4
	Junior	22	13.0
	Senior	57	33.7
Community	Rural	48	57.4
	Urban	120	42.6
Course type	Biology	48	28.4
	Agriculture	120	71.0

N = 169.

the complementary strengths of both quantitative and qualitative methods and allow for more rich, robust analysis (Greene et al., 1989). This inquiry was guided by a critical realist paradigm (Gorski, 2013). While dominant research approaches in physical sciences emphasize an “imperative of proof,” this research adopts an “imperative of understanding”—elevating rich and complex contextual descriptions above generalizable simplicity (Regehr, 2010). Validity procedures included triangulating sources of data, intercoder agreement, in-depth case descriptions, researcher reflexivity, collaboration with participants, and peer debriefing (Lincoln and Guba, 1985; Creswell, 1998, 2003). Quantitative measures included student poultry knowledge comprehension tests before and after each module, and measures of student individual interest on a pre- and post-program survey. Qualitative data included student and teacher responses on open-ended questions in the pre- and post-program surveys and statements from a teacher focus group.

Poultry Knowledge Comprehension Tests

Immediately prior and following the first 6 modules, students completed 10-question, 10-point content quizzes on module content. Poultry experts assisted in developing content quizzes to test student comprehension of each module’s content. The expert panel and 2 volunteers not involved with the research reviewed the content quizzes to establish face and content validity.

Survey Instrumentation and Administration

The student pre-program questionnaire comprised demographic information and Likert scale items to measure poultry interest adapted from the Individual Interest Questionnaire (**IIQ**) developed by Rotgans (2015; see appendix). The IIQ’s construct and predictive validity as a measure of individual interest has been established across a wide range of educational settings (Rotgans, 2015). Cronbach’s alpha coefficient for the IIQ was 0.97, suggesting excellent internal consistency of the instrument in our sample (Tavakol and Dennick, 2011). Poultry interest was again assessed in the post-program questionnaire. In addition, the post-questionnaire included open-ended questions on students’ perceptions of the learning experience. Because participants were geographically dispersed, the survey was administered through an online survey platform (Qualtrics, Provo, UT). The survey required completion of each question before advancing. Students completed the pre-program questionnaire immediately prior to beginning the program. All participants completed the post-questionnaire following the program and within 16 wk of the program start date.

Teacher Focus Group

All teachers were invited to participate in a focus group held within 1 wk of the program’s completion. During the focus group, a trained facilitator used semistructured prompts to lead the 3 teachers in attendance in discussion surrounding program effectiveness, effects on students, and design features. Teacher responses were audio-recorded and transcribed verbatim using an online service (Verbal Ink, Ubiqus).

Data Analysis

Quantitative statistical analyses were performed using SAS software (SAS Institute Inc, 2013). First, Shapiro-Wilk and Levene’s tests were used to confirm normality and homogeneity of variance, respectively. Summary statistics were computed using PROC MEANS. Next, paired t-tests were used to assess differences in pre-test and post-test knowledge for each module and for differences in pre-program and post-program poultry interest. Significance was declared at $P < 0.05$.

The study’s qualitative phase employed a descriptive approach to analyze open-ended responses from the survey and focus group (Sandelowski, 2000). Qualitative description is a form of naturalistic inquiry that is well suited for exploratory research and can produce rich descriptions and interpretations of social phenomena (Salkind, 2010). Student and teacher responses were coded using the thematic analysis procedure outlined by Braun and Clarke (2006). This inductive categorization involved minimal interpretation of data. Finally, themes were organized under a priori categories based on the research objectives. Intercoder agreement was achieved using the collaborative coding procedure outlined by Richards et al. (2018). Selected representative participant responses are presented for each theme.

RESULTS

Participants’ Knowledge, Awareness, and Interest

Both quantitative results and qualitative statements indicated that high school students’ knowledge and comprehension of the poultry industry was higher upon

Table 4. Paired t-test comparison of mean student scores on 10-point content quizzes before and after each module of online poultry-STEM program

Module	M-Pre	M-Post	*t*	*df*	*P*-value	*d*
1	4.28 ± 0.12	6.25 ± 0.18	10.41	168	<0.0001	0.80
2	3.02 ± 0.11	4.95 ± 0.20	10.03		<0.0001	0.77
3	5.92 ± 0.19	7.27 ± 0.19	8.16		<0.0001	0.63
4	4.58 ± 0.15	5.69 ± 0.17	6.53		<0.0001	0.50
5	3.89 ± 0.13	4.94 ± 0.17	5.85		<0.0001	0.45
6	4.66 ± 0.16	6.41 ± 0.20	8.65		<0.0001	0.67

N = 169.

Data shown are average score out of 10 points possible ± SEM. The table shows t-test comparisons of pre-test and post-test scores for each module. Cohen's d effect sizes are presented for each comparison.

completion of the program. Table 4 summarizes comparisons of average student scores between the pre-test and post-test of each module. For each module, a significant increase in performance was observed. With one exception, Cohen's d effect size was moderate to large for the increase in content quiz performance, indicating moderate to large magnitude differences between pre- and post-module mean quiz scores (Durlak, 2009). A paired t-test indicated no difference in students' average IIQ-based interest in poultry before ($M = 1.84 \pm 0.06$) and following ($M = 1.87 \pm 0.07$) the program ($p = 0.67$, $df = 168$). Participants' qualitative responses, summarized in Table 6 with representative quotes, offered further insight regarding students' knowledge, awareness, and interest after completing the program.

Students described starting the program with low knowledge of poultry, low confidence in their abilities, and low interest in the subject. As one student commented, "There wasn't much I understood at the beginning of the module learning. I understand a lot more now." As students gained poultry knowledge, they also reported developing more confidence, as this student statement illustrates: "My confidence is much higher at learning and absorbing new information about poultry." Many students reported that the program stimulated curiosity in the subject—helping them learn more as they completed the program. "I have started to want to learn more about poultry through each module," a student stated.

Although students appeared to enjoy the program, many expressed doubts about the relevance of poultry science to their lives. "I won't ever go into [poultry]…but it was fun to learn about." While several students claimed the topic itself was inherently uninteresting, others mentioned feeling uninterested because they did not plan to pursue a related career. Teachers commented that students with low prior exposure to poultry had more difficulty seeing relevance in the program. For example, one teacher commented "I believe students need to have a basic animal science knowledge base to appreciate the modules." Further feedback from teachers is summarized in Table 5.

Students mentioned that the program improved their views of the poultry industry: both increasing their understanding of the industry's complexity and enhancing their opinion towards it. One student's comment captures the shared sentiment: "There's so much more to something that I thought was so simple." Several statements indicated that the program prompted students to take the perspective of those involved in the poultry industry. Teachers appeared to agree that program participation had broad benefits to students' understanding of the poultry industry and agriculture. Similarly, both teacher and student statements supported that program participation increased students' awareness of the range of available poultry careers and the requirements involved in each.

Table 5. Teacher post-survey responses on effectiveness of online poultry-STEM program in classrooms.

M	Item
4.71 ± 0.66	It helped me improve my instruction of poultry science concepts and skills.
5.57 ± 0.28	It helped me show my students career opportunities in poultry science.
5.14 ± 1.68	It allowed me to incorporate content that is outside my expertise.
5.71 ± 0.39	It allowed me to go beyond my normal teaching content and methods.
6.00 ± 0.29	It helped my students learn poultry science concepts and skills.

Data presented are average teacher rating on a Likert scale from (1–"strongly disagree" to 7–"strongly agree") ± SEM. N = 7.

Program Instructional Design

Based on qualitative data (Table 6), the program's instructional design was well received by both students and teachers. Students mentioned appreciating having immersive, interactive learning opportunities through multiple platforms. The program's varied and challenging content appeared to increase both students' interest in the topic and their perceived comprehension of it. However, some students and teachers found the program's online platform restricted its interactivity. Students mentioned a need for more games and interactive components. According to teachers, hands-on activities or a stronger in-class component might have enhanced learning.

DISCUSSION

Our study is the first to our knowledge to document the effectiveness of an online poultry science education program for high school students. This project was undertaken to create poultry learning resources using principles of learner-centered instructional design and evaluate their effectiveness in a pilot sample of classrooms. Overall, the program appears to have served as an effective poultry learning resource for our sample. High school students shared: they were more aware, knowledgeable, and sometimes more interested in poultry after completing the modules.

The significant, moderate to large increases in mean content quiz score for all modules indicate that

Table 6. Representative statements from students and teachers for themes related to program effects on knowledge, awareness, and interest.

Program Participation Increased Knowledge of Poultry Science and the Industry	
Students	"There wasn't much I understood at the beginning of the module learning. I understand a lot more now."
	"As I have been doing this program my knowledge about poultry is much greater, and I am more confident when it comes to talking about poultry."
Program Made Participants More Confident in Ability to Succeed in Poultry	
Students	"I am confident in my new ability to understand poultry terms."
	"I feel more confident talking about poultry because I have learned a lot about chickens and how to maintain them."
Program Increased Participants' Interest in Poultry	
Students	"I have wanted to learn more because I found the poultry modules interesting."
	"I have started to want to learn more about poultry through each module."
	"It has intrigued me and I have learned a lot more about chickens than I ever thought before."
Program Not Relevant or Enjoyable for Students Without Pre-Existing Poultry Interest	
Students	"They were not valuable at all because I had no interest in learning about poultry."
	"The games are not fun or engaging unless you already care about poultry."
	"It is just hard for me to enjoy because I don't want to get a career in poultry."
Teachers	"I believe students need to have a basic animal science knowledge base to appreciate the modules."
Program Participation Changed Perceptions of Poultry Industry	
Students	"It showed me how much effort it takes to raise a flock, it makes me have more respect for this field of work."
	"There's so much more to something that I thought was so simple."
Program Participation Increased Awareness of Poultry Careers	
Students	"I now understand how many job opportunities there are in poultry."
	"It taught me about how people do these jobs and why they are actually very important."
Teachers	"As far as from a career standpoint, one thing—one of my students made the comment, she says, "I didn"t know there was that many jobs. I didn't know there was that many different things to it.' … It was a little bit of an eye opener on just what all is involved versus what they have as a mindset."
Varied, Interactive Instructional Design in Program Enhanced Learning and Interest	
Students	"I felt like I was actually there with the chickens and I found it really fun."
	"They had an interactive part to them which helped me be intrigued with the topic."
	"They made things about chickens easier to understand."
	"It taught us how to care for chickens in a real-life and visible way."
Predominantly Online Platform was Boring, More Hands-on Components Needed	
Teachers	"It also needs a project (hands-on activity) to go with it to reaffirm what they just learned."
	"More interactive, more things that interest the students. Like hatching eggs, learning to candle. They need more hands on in order to learn."

participants had more poultry knowledge after the program than before. Although our experimental design prohibits causal inference, the proximity of testing relative to the experience and participants' blindness to correct responses strengthen the internal validity of content knowledge results. However, the pre-test and post-test for each module contained identical questions. Therefore, the post-test was susceptible to testing effects (e.g., habituation, sensitization, fatigue; Cronbach, 1982).

In addition to quantitative gains in poultry science knowledge, student and teacher statements and quantitative teacher questionnaire results portray the program as benefitting students' understanding of the poultry industry and related careers. Many statements indicate that increased understanding was accompanied by shifts to more positive attitudes towards the poultry industry. We suggest that the program's activities and simulation games, which encouraged students to adopt the perspective of someone involved in the poultry industry, may have contributed to the development of more positive attitudes. Perspective-taking has been demonstrated to improve attitudes towards outgroups by creating empathy and enhancing awareness of situational factors involved in the outgroup's stereotypical behavior (Vescio et al., 2003). The program's intentional efforts to resolve misconceptions and improve sentiments towards the poultry industry appear to have been effective, based on qualitative data.

Both declarative and attitudinal learning (i.e., changes in content knowledge and in attitudes, respectively) during the program were likely moderated by students' interest in the program activities and in poultry as a subject. Interest is a powerful motivator of learning and achievement that is intertwined with affective reactions, cognition, and values (Harackiewicz et al., 2016). Predominant theorists typically separate interest into 2 main forms: a transitory psychological state of focused attention and positive affect (situational interest) and an individual trait-like preference for a topic over time (individual interest; Hidi and Renninger, 2006). While individual interest is relatively stable, situational interest can be activated by features of learning tasks. For example, our program employed vivid, organized, inquiry-based learning opportunities to increase situational interest (Schraw et al., 1995). Over time, repeated or prolonged situational interest can lead to the development of more stable individual interest in the topic (Hidi and Renninger, 2006).

In our study, students indicated that their initial individual interest in poultry was low. While many students commented that the program created situational interest and subsequently increased their individual interest in poultry topics, others' statements indicated that they remained uninterested in poultry at the program's conclusion. Quantitatively, we observed no difference in students' mean individual interest in poultry before and following the program. This is unsurprising. Although the learning and motivational benefits of well-developed individual interest make it an attractive target for educational interventions, individual interest is relatively stable (Harackiewicz et al., 2016). Changes to individual interest may require exposure over an extended timeframe or through multiple contexts (Hidi and Renninger, 2006). These conditions were outside the scope of our semester-long online program. Testing effects, maturation of subjects, and response shift bias may also have influenced quantitative data (Cronbach, 1982).

Alternatively, student statements point to another factor which may explain the lack of individual interest development in students: low perceived relevance of poultry topics. Prevailing interest theories suggest that 3 interrelated factors facilitate the formation of long-term interest: knowledge, positive emotion, and personal value (Harackiewicz and Hulleman, 2010). Our program was designed to increase participants' knowledge of poultry, create positive affect through engaging learning experiences, and enhance personal value by demonstrating relevance of content. Although qualitative and quantitative data indicate that our program enhanced knowledge and was enjoyable, it appears many students did not perceive content as relevant to their lives and goals.

Well-designed instruction can enhance perceived relevance by making connections between the content and students' lives explicit or requiring students to self-generate task-value messages (Hulleman et al., 2010; Rozek et al., 2017). However, perceived relevance is interactional and varies for groups of learners and with certain subjects (Jones and Young, 1995). Certain knowledge domains may face more difficulties creating interest in many populations. For example, a large body of literature documents low interest in mathematics—a condition which is exacerbated during middle adolescence and within underrepresented groups (Watt, 2004; Høgheim and Reber, 2017). Some have even implicated low interest in STEM subjects in creating workforce and STEM literacy deficiencies (Linnenbrink-Garcia et al., 2018).

As the subject of instruction, poultry science presents opportunities and challenges to educational developers. As practitioners within the field will appreciate, poultry science is practical, dynamic, and diverse: offering many options for various types of learners and learning (Romanelli et al., 2009). However, the public is largely unfamiliar with poultry science topics (Spain et al., 2018). As a consequence, poultry science topics will be novel to many populations. Although the vividness and novelty of poultry science may effectively create short-term interest, the development of long-term knowledge and interest requires that learners perceive relevance: making meaningful connections between content, prior knowledge, and personal values (Palmer, 2009; Hulleman et al., 2010). When working with subjects like poultry science where these connections are less apparent to learners, instructional developers face greater challenges demonstrating relevance.

Recent studies, however, show promise that research-based educational interventions have the potential to support interest in content areas where the relevance of topics is less apparent to learners (Rosenzweig and Wigfield, 2016). For instance, techniques such as context personalization and hands-on learning have been shown to increase motivation in populations with low initial interest (Holstermann et al., 2010; Walkington, 2013). Our study participants themselves hinted at a desire for more hands-on, interactive components and options for students with less prior experience. This may indicate that our predominantly online platform limited student interest development during our program, and that future programs including more hands-on, personalized learning (e.g., facility tours, live birds, group activities, meeting poultry experts in person) can succeed in creating enduring interest in poultry. Although these findings offer direction, implementing real educational programs involves coordinating numerous interacting techniques amid various contextual factors and with diverse groups of learners (Eccles and Wigfield, 2002). Future work is needed to inform the development of effective multi-faceted, research-based educational interventions similar to the one in our study (Linnenbrink-Garcia et al., 2018).

In summary, the online poultry education program in this study appears to have improved knowledge and attitudes towards the poultry industry in our sample. Although the generalizability of our investigation was limited by a small, convenience sample and low response rate, participants' descriptions of their experiences showed that learner-centered poultry education programs can create positive poultry learning experiences for many high school students. Still, further research is needed to explore methods for enhancing poultry science's perceived relevance to students. Our study and future similar work will serve to inform the implementation of poultry learning within K-12 curricula to improve public agricultural literacy and support poultry workforce needs.

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REFERENCES

Azevedo, R., and M. J. Jacobson. 2007. Advances in scaffolding learning with hypertext and hypermedia: a summary and critical analysis. Educ. Tech. Res. Dev. 56:93–100.

Barton, P. 2009. National Education Standards: Getting Beneath the Surface. Educational Testing Service, Princeton, NJ.

Bautista, N. U. 2011. Investigating the use of vicarious and mastery experiences in influencing early childhood education majors' self-efficacy beliefs. J. Sci. Teach. Educ. 22:333–349.

Braun, V., and V. Clarke. 2006. Using thematic analysis in psychology. Qual. Res. Psychol. 3:77–101.

Bybee, R. W. 2010. Advancing STEM education: a 2020 vision. Tech. Engr. Teach. 70:30–35.

Creswell, J. W. 1998. Qualitative Inquiry and Research Design: Choosing Among Five Traditions. Sage Publications, Inc, Thousand Oaks, CA.

Creswell, J. W. 2003. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 2nd ed. Sage, Thousand Oaks, CA.

Cronbach, L. 1982. Designing Evaluations of Educational and Social Programs. Jossey-Bass, San Francisco.

Daigle, C. L. 2014. Incorporating the philosophy of technology into animal welfare assessment. J. Agric. Environ. Ethics. 27:633–647.

Deci, E. L., and R. M. Ryan. 1985. Toward an organismic integration theory. In: Intrinsic Motivation and Self-Determination in Human Behavior, Springer, Boston, MA.

Durlak, J. A. 2009. How to select, calculate, and interpret effect sizes. J. Pediatr. Psychiol. 34:917–928.

Eccles, J. S., and A. Wigfield. 2002. Motivational beliefs, values, and goals. Annu. Rev. Psychol., 53:109–132.

Erian, I., and C. Phillips. 2017. Public understanding and attitudes towards meat chicken production and relations to consumption. Animals. 7:20.

Gorski, P. C. 2013. Building a pedagogy of engagement for students in poverty. Phi Delta Kappan. 95:48–52.

Greene, J., V. Caracelli, and W. Graham. 1989. Toward a conceptual framework for mixed-method evaluation designs. Educ. Eval. Policy Anal. 11:255–274.

Harackiewicz, J. M., and C. S. Hulleman. 2010. The importance of interest: the role of achievement goals and task values in promoting the development of interest. Soc. Personal Psychol. Compass. 4:42–52.

Harackiewicz, J. M., J. L. Smith, and S. J. Priniski. 2016. Interest matters: the importance of promoting interest in education. Policy Insights Behav. Brain Sci. 3:220–227.

Hidi, S., and K. A. Renninger. 2006. The four-phase model of interest development. Educ. Psychol. 41:111–127.

Høgheim, S., and R. Reber. 2017. Interesting, but less interested: gender differences and similarities in mathematics interest. Scand. J. Educ. Res. 63:285–299.

Holstermann, N., D. Grube, and S. Bögeholz. 2010. Hands-on activities and their influence on students' interest. Res. Sci. Educ. 40:743.

Hulleman, C. S., O. Godes, B. L. Hendricks, and J. M. Harackiewicz. 2010. Enhancing interest and performance with a utility value intervention. J. Educ. Psychol. 102:880–895.

Johnson, B., and L. A Turner. 2003. Data collection strategies in mixed methods research. Pages 297–319 in Handbook of Mixed Methods in Social and Behavioral Research, A. M. Tashakkori, and C. B. Teddlie, eds. SAGE Publications, Thousand Oaks.

Jones, J., and D. Young. 1995. Perceptions of the relevance of mathematics and science: an Australian study. Res. Sci. Educ. 25:3–18.

Keller, J. M. 1987. Development and use of the ARCS model of instructional design. J. Instr. Des. 10:2–10.

Lincoln, Y. S., and E. G. Guba. 1985. Naturalistic Inquiry. Sage Publications, Beverly Hills, CA.

Linnenbrink-Garcia, L., T. Perez, M. M. Barger, S. V. Wormington, E. Godin, K. E. Snyder, K. Robinson, A. Sarkar, L. S. Richman, and R. Schwartz-Bloom. 2018. Repairing the leaky pipeline: a motivationally supportive intervention to enhance persistence in undergraduate science pathways. Contemp. Educ. Psychol. 53:181–195.

Messersmith, E. E., J. L. Garrett, P. E. Davis-Kean, O. Malanchuk, and J. S. Eccles. 2008. Career development from adolescence through emerging adulthood. J. Adolesc. Res. 23:206–227.

Moore, T. J., M. S. Stohlmann, H. H. Wang, K. M. Tank, A. W. Glancy, and G. H. Roehrig. 2014. Implementation and integration of engineering in K-12 STEM education. Pages 35–60 in Engineering in Pre-College Settings: Synthesizing Research, Policy, and Practices. Purdue University Press, West Lafayette, IN.

National Academy of Engineering and National Research Council. 2014. STEM Integration in k-12 Education: Status, Prospects, and an Agenda for Research. The National Academies Press, Washington, DC.

Ortega, R.R. 2011. Motivation and career outcomes of a precollege life science experience for underrepresented minorities. PhD Diss. Purdue Univ., West Lafayette.

Osborne, E., and J. Dyer. 2000. Attitudes of Illinois agriscience students and their parents toward agriculture and agricultural education programs. J. Agric. Educ. 41:50–59.

Palmer, D. H. 2009. Student interest generated during an inquiry skills lesson. J. Res. Sci. Teach. 46:147–165.

Regehr, G. 2010. It's NOT rocket science: Rethinking our metaphors for research in health professions education. Med. Educ. 44:31–39.

Richards, K. A., M. A. Hemphill, and T. J. Templin. 2018. Personal and contextual factors related to teachers' experience with stress and burnout. Teachers Teaching 24:768–787.

Robinson, K., D. Westfall-Rudd, T. Drape, and H. Scherer. 2018. Conceptualizing integrative agricultural education: introductory framework for integrating mathematics in agricultural curriculum. J. Agric. Educ. 59:253–269.

Romanelli, F., E. Bird, and M. Ryan. 2009. Learning styles: a review of theory, application, and best practices. Am. J. Pharm. Educ. 73:9.

Rosenzweig, E. Q., and A. Wigfield. 2016. STEM motivation interventions for adolescents: a promising start, but further to go. Educ. Psychol. 1:146–163.

Rotgans, J. I. 2015. Validation study of a general subject-matter interest measure: the individual interest questionnaire (IIQ). Health Prof. Educ. 1:67–75.

Rozek, C. S., R. C. Svoboda, J. M. Harackiewicz, C. S. Hulleman, and J. S. Hyde. 2017. Utility-value intervention with parents increases students' STEM preparation and career pursuit. Proc. Natl. Acad. Sci. USA. 114:909–914.

Salkind, N. J. 2010. Encyclopedia of Research Design. SAGE reference, Los Angeles.

Sandelowski, M. 2000. Whatever happened to qualitative description? Res. Nurs. Health. 23:334–340.

SAS Institute Inc 2013. SAS/ACCESS® 9.3.SAS Institute Inc, Cary, NC.

Schunk, D. H., and J. L. Meece. 2006. Self-efficacy development in adolescence. Pages 71–96 in Self-Efficacy Beliefs of Adolescents. F. Pajares, and T. Urdan, eds. Information Age Publishing, Greenwich, CT.

Schraw, G., R. Bruning, and C. Svoboda. 1995. Sources of situational interest. J. Read. Behav., 27:1–17.

Spain, C., D. Freund, H. Mohan-Gibbons, R. Meadow, and L. Beacham. 2018. Are they buying it? United States consumers' changing attitudes toward more humanely raised meat, eggs, and dairy. Animals. 8:128.

Tavakol, M., and R. Dennick. 2011. Making sense of Cronbach's alpha. Int. J. Med. Educ. 2:53–55.

Vasquez, J., C. Sneider, and M. Comer. 2013. STEM Lesson Essentials, Grades 3–8: Integrating Science, Technology, Engineering, and Mathematics. Heinemann, Portsmouth, NH.

Vescio, T. K., G. B. Sechrist, and M. P. Paolucci. 2003. Perspective taking and prejudice reduction: the mediational role of empathy arousal and situational attributions. Eur. J. Soc. Psychol. 33:455–472.

Wang, H., T.J. Moore, G.H. Roehrig, and M.S. Park. 2011. STEM integration: teacher perceptions and practice. J. Precoll. Eng. Educ. Res. 1:1–13.

Walkington, C. A. 2013. Using adaptive learning technologies to personalize instruction to student interests: the impact of relevant contexts on performance and learning outcomes. J. Educ. Psychol. 105:932–945.

Watt, H. M. 2004. Development of adolescents' self-perceptions, values, and task perceptions according to gender and domain in

7th- through 11th-grade Australian students. Child Dev. 75:1556–1574.
Yin, R. K. 2013. Case Study Research. Sage, Los Angeles, CA.

APPENDIX

Poultry Individual Interest Questionnaire

(adapted from Rotgans, 2015)

- I am very interested in poultry science.
- Outside of school I read a lot about poultry.
- I always look forward to learning about poultry lessons a lot.
- I have been interested in poultry since I was young.
- I follow a lot of poultry topics on social media.
- Later in my life I want to pursue a career in poultry science or a poultry-related discipline.
- When I am reading something about poultry or watch something about poultry on video, I am fully focused and forget everything around me.