INTEREST AND MOTIVATION IN LEARNER-CENTERED ANIMAL SCIENCES EDUCATION

by

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To my mother

who taught me curiosity, generosity, and a healthy disregard for limitations

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

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This thesis examines learner-centered animal science education and its relationships with emotion, motivation and performance. Part I focuses on active learning strategies implemented in an introductory animal sciences course. This large-enrollment course had traditionally been taught through traditional, passive learning methods. Instructors added learning activities such as case studies and hands-on laboratory stations to supplement lecture-based instruction. Chapter Two summarizes the impacts of different active learning techniques implemented in the course and characterizes students enrolled in the course based on their interests, past experiences, and demographic information. Building on these findings, Chapter Three describes an experiment quantitatively comparing the effects of three learning strategies (lecture, case study, and laboratory station) on students' experience of interest and motivation. In both studies, students rated themselves highly interested in animal sciences throughout the semester. More collaborative, problem-based instructional methods (i.e. laboratory stations and case studies) were favored by students and resulted in higher student interest and internalized motivation. Results presented in Part I may inform the creation of instructional techniques to support student motivation, retention, and performance. Part II describes an online learning program contextualizing STEM learning within poultry science and implemented in high school classrooms during the fall 2018 semester. The program was designed to increase students' knowledge and interest in both poultry and STEM fields to support the development of poultry- and STEM-literacy and meet workforce needs. Chapter Four describes program effects on students' knowledge, awareness, and interest in the poultry industry. In contrast, Chapter Five focuses on the program's effects on students' STEM learning and STEM motivation. In addition, Chapter Five provides background on teacher and contextual factors influencing the program's implementation. Results from these studies indicate that the program effectively increased students' STEM and poultry knowledge, and increased motivation for some students. However, other qualitative and quantitative data indicated that some

students experienced difficulties relating content to their lives. In addition, the program's effects on students differed substantially based on teachers and classroom implementation. Both students and teachers also mentioned a need for more hands-on, collaborative elements in the program. Although results from Part II show promise that contextualizing STEM learning within agriculture may effectively increase knowledge and motivation, more research is needed to understand how to select and personalize contexts to maximize their relevance to students, and how to support teachers in effectively implementing these approaches. In conclusion, learner-centered instructional strategies such as problem-based and hands-on learning can be designed to enhance students' interest, motivation, and performance. However, more research is needed to understand the complex personal and contextual factors moderating the effectiveness of these approaches when implemented in authentic classroom settings. Future studies clarifying these effects can advance the development of theory-based educational resources.

CHAPTER 1. INTRODUCTION AND LITERATURE REVIEW

The President's Council of Advisors on Science and Technology has projected a need for 1 million more science, technology, engineering, and mathematics (STEM) professionals over the next decade and called for a 33% increase in the number of STEM bachelor's degrees completed per year (PCAST, 2012). Central to the shortage issue is a lack of persistence among STEM enrollees—what some have termed a defective "pipeline" or "pathway" to STEM careers (Cannady, Greenwald, & Harris, 2014). A study by Kober (2015) following 17,000 post-secondary students in the U.S. reported that only two-fifths of students who enrolled in STEM programs went on to earn their degree or continue study in the field. The problem is exaggerated in at-risk populations, where as many as 80% of students switch to a non-STEM field or drop out (PCAST, 2012).

In addition to highlighting the need for more STEM graduates, the National Science Board's (NSB) recent report *Revisiting the STEM Workforce* draws attention to the growing need for advanced STEM skills in non-STEM careers (NSB, 2015). In 2010, 16.5 million Americans reported that their job required at least a bachelor's degree level of science and engineering expertise. Yet, only 5.4 million individuals are classified as working in science and engineering. Indeed, the concept of a "STEM workforce" has been poorly defined. Various pathways lead to STEM skill development and use in careers. Because STEM skills are important in jobs across the economy, the NSB report calls for building a "strong, STEM-capable" U.S. workforce (NSB, 2015).

As governments, educational institutions, and employers work to build the 21st century workforce, accessible and effective STEM education and training resources are critical (PCAST, 2012). Policy-makers, administrators, and teachers are turning to a wide variety of educational techniques in and out of the classroom to address these needs. A large body of literature documents the effectiveness of STEM-pipeline-strengthening programs including short-term interventions, outreach programs, and curricular reform (Hurk et al., 2018). In many cases, these programs employ a learner-centered approach and focus on creating interest and motivation towards STEM fields.

Research on motivation and persistence in STEM fields presents many opportunities for strengthening the STEM pipeline. Past research has identified a number of individual differences explaining variability in educational and career performance (Richardson et al., 2004). Traditionally, measures of cognitive ability and personality have figured prominently in research (Robbins et al., 2004). However, recent research has highlighted the importance of non-ability personal traits such as motivation in predicting academic and career success (Richardson et al., 2014). In addition, education research has recently emphasized the importance of emotional states in students' learning and developmental trajectories (Pekrun & Linnenbrink-Garcia, 2014).

1.1 Theoretical Perspectives on Determinants of Behavior

Understanding motivated behavior and its sources first requires a general understanding of human behavior and the causal structure underlying. Historically, human behavior has often been explained in terms of unidirectional determinism. For example, the tradition of biological determinism attributes human behavior to genetic or biological sources (Chorney et al., 1998). On the other hand, behaviorist ideologies describe human behavior as mechanical reactions to environmental stimuli (Skinner, 1971). Still other theoretical perspectives emphasize human agency, the capacity of individuals to influence themselves and their environments (Bandura, 1989). Modern theories adopt an intermediate perspective, conceiving of behavior as interactionist: neither as wholly autonomous nor as mechanically reactive. For example, social cognitive theory proposes a model of triadic reciprocal causation underlying psychosocial functioning (Bandura, 1986). Interactions between person, environment, and behavior are reciprocal in nature.

1.2 Psychological Processes of Learning

In their influential work, Snow, Corno, and Jackson (1996) proposed three main psychological components of human learning: cognition, affection, and conation. Cognition refers to mental processes associated with knowledge and understanding, such as thinking, judging, and problem-solving (Ainley, 2006). On the other hand, affection represents temperament and emotions (Snow, Corno, & Jackson, 1996). Finally, conation refers to volition and motivation: processes that drive goal-directed behaviors (Crocker et al., 2013).

The three components—cognition, emotion, and motivation—are intricately related. For example, cognitive appraisals of actual versus expected performance can create emotional responses that affect motivation (Carver, 2006). Alternatively, positive affect created by interest-driven learning can enhance motivation and improve cognitive processing (Linnenbrink, 2006). Indeed, some have argued that emotion, motivation, and cognition are so intricately related that they cannot be separated (Buck, 2000). Despite this, research on learning has lacked an integrated approach, with theorists and researchers tending to study these phenomena in isolation and often neglecting the role of emotion (Ford, 1992). For example, prominent theories such as self-determination theory and expectancy-value theory capture only cognitive and motivational components of learning—relegating emotion to an ancillary role (Meyer & Turner, 2002). As the focus of education research advances, integrated approaches to understanding effective practices for enhancing learning may direct theory and research.

1.2.1 Motivational Traits

Educational research has traditionally encompassed the full range of affective, cognitive, and motivational variables. However, some aspects within each domain are more readily accessible to educators than others. For example, certain predictors of academic and career performance are relatively stable—not readily influenceable by the context (Murphy & Alexander, 2000). For example, intelligence and dispositional personality traits may be mediated in part by genetics, with heritability estimates ranging from 0.50 to 0.80 (Plomin, 2001; Riemann, Angleitner, & Strelau, 1997). In contrast, motivational contributions to performance are dynamic, and bound to context (Richardson, Abraham, & Bond, 2012). As a result, motivation-related traits such as expectancies, goals, and the use of self-regulatory learning strategies may be learnable or malleable through changes to the educational context (Carver & Scheier, 1981).

1.2.2 Motivational States

Motivational traits are intricately linked with motivational states (i.e. situational experiences of motivation). The experience of motivation is associated with a range of "affective, cognitive, physiological, and expressive components" (Kleinginna & Kleinginna, 1981). In coordination, these psychological processes constitute emotions (Pekrun & Linnenbrink-Garcia, 2014). Emotional experiences are instrumental in academic achievement and personal development. To illustrate, Linnenbrink-Garcia and Pekrun offer the following example:

> "…experiencing enjoyment while working on a challenging project can help a student envision goals, promote creative and flexible problem-solving, and support self-regulation. On the other hand, experiencing

> excessive anxiety about exams can impede a student's academic performance, compel him to drop out of school, and negatively influence his psychological and physical health."

Positive emotional states can facilitate internalization of motivation and support self-regulated learning (Clore & Huntsinger, 2009). Despite the clear importance of emotions in education, teachers often receive little to no training in the principles of emotion and learning. However, in recent decades research in this area has steadily increased (Pekrun & Linnenbrink-Garcia, 2014). Future educational research clarifying the important role of emotion in learning may translate to more effective teaching practices.

1.2.3 Motivational Interventions

In education research, experimental studies often center on interventions—empirical examinations in which an independent variable is manipulated (Lazowski & Hulleman, 2015). A great deal of research documents the benefits of motivational interventions across different academic domains (Wentzel & Wigfield, 2007). Recently, Rosenzweig and Wigfield (2012) reviewed work on a wide range of motivational interventions in STEM domains. The authors concluded that interventions based on motivation theory can produce significant improvements across a variety of academic achievement and motivation outcomes including STEM course-taking, exam performance, and use of learning strategies. However, the authors note that interventions vary substantially in their effects and call for future research clarifying specific aspects of motivational interventions and illuminating the individual and contextual factors moderating their effectiveness (Rosenzweig & Wigfield, 2016).

1.3 Self-Determination Theory of Motivation

Although a general theoretical framework for understanding causal structures underlying human behavior is prerequisite, understanding motivated behaviors—in particular the behaviors associated with STEM persistence and achievement—requires additional theoretical consideration. A number of interactionist theories characterize motivation and associated processes. One of the most prominent in modern education research is self-determination theory (SDT) (Dyrberg & Holmegaard, 2019). Among theories, SDT is uniquely suited to understanding the intrinsic interest and curiosity driving STEM persistence. Unlike other theories focusing on expectations, beliefs, and goals, Self-determination theory emphasizes "vitalizing students' inner motivational resources" (Reeve & Halusic, 2009). Past studies have shown interest and enjoyment are primary drivers of persistence in STEM fields (McGee & Keller, 2007; Rayman & Brett, 1995).

While other theories focus on goals or outcomes and the instrumentalities leading to their achievement, self-determination theory is more holistic: concerning not only the direction of behavior but also its purpose (Deci et al., 1991). To this end, SDT suggests three innate psychological needs which govern self-determined behavior and lead to well-being. Self-determination theory revolves around the idea of intrinsic motivation—an individual's "tendency to seek out novelty and challenges, to exercise one's capacities, to explore, and to learn" (Deci and Ryan, 2000). Intrinsic motivation is characterized by self-determined regulation, in which actions are volitional and endorsed by one's sense of self (Deci et al., 1991). Positive outcomes (achievement, personal growth, adjustment, etc.) manifest when individuals experience intrinsic or highly internalized motivation (Deci et al., 1991).

According to self-determination theory, intrinsic motivation can result either from inherently interesting activities, or a process within the individual of internalizing values or regulatory processes associated with uninteresting activities (Deci et al., 1994). Actions governed by internalized values or enjoyment can be described as intrinsically motivated, while those that stem from external forces such as social pressure or rewards are extrinsically motivated (Deci & Ryan, 1985). Extrinsic motivation can exist in several forms, ranging from very low (e.g. external regulation) to very high (e.g. identified regulation) levels of internalization (Sansone, 2000). Important functional differences exist between the types of motivation. The highest levels of performance, persistence, and creativity are associated with more self-determined forms of motivation (Deci & Ryan, 2000). More internalized, integrated motivation also tends to be associated with greater enjoyment, satisfaction, and well-being (Vallerand, 1988).

A number of contextual factors influence the internalization process. Self-determination theory organizes contextual support for internalization in terms of satisfaction of basic psychological needs (Deci & Ryan, 1985). Drawing on Nuttin's (1984) relational theory of behavioral dynamics, self-determination theory assumes that humans have innate needs to experience competence, autonomy, and relatedness. Competence refers to perceptions of ability to succeed and the experience of mastery, while autonomy is the perception of causal agency, and relatedness is the perception of social connectedness (Deci & Ryan, 1985). Support of basic psychological needs enhances self-determination of motivation (Deci et al., 2006). As a result, a great deal of education research has focused on creating motivating contexts for learning (Sansone, 2000). Instructional designers can improve motivation both by making activities more inherently interesting and by structuring contextual supports for motivation in the learning environment (Deci et al., 2006).

The distinction between inherently interesting *tasks* and motivating *environments* illustrates that motivation can be influenced at several levels of generality. Vallerand's Hierarchical Model of Motivation (1997) orders motivation into three tiers: situational, contextual, and global. Situational motivation refers to the motivation experienced when individuals are engaged in an activity: what Vallerand calls the "here and now" of motivation. Contextual motivation concerns an individual's motivational orientation within a specific context such as education, work, or leisure activities. At the highest level of generality, global motivation refers to relatively enduring individual differences in motivational orientation independent of context (Vallerand, 1997). Deci and Ryan's extrinsic-intrinsic motivation continuum exists at each tier, and motivation development at each tier is bidirectionally related to that of adjacent tiers (Vallerand, 1997).

Educators and instructional designers have access to influence motivation at the situational and contextual levels (Vallerand, 1997). At the situational level, design principles can be employed to create activities which inherently capture interest (Schraw, 2001). At the contextual level, changes to classroom environments and institutional culture can support self-determination of motivation (Ryan & Deci, 1985). Because self-determination theory focuses on internalization of regulation for relatively uninteresting activities, much of the associated research examines contextual support for basic psychological needs (Niemec & Ryan, 2009). By supporting competence, autonomy, and relatedness, secondary and tertiary (i.e., undergraduate) instructors can facilitate internalization of motivation for STEM performance.

1.3.1 Contextual Support of Autonomy

Perhaps the most widely-researched self-determination theory-based principle is contextual support of autonomy (Niemec & Ryan, 2009). Teachers can alter classroom climates to support or control students' behavior, influencing student perceptions of autonomy and subsequent intrinsic motivation. In autonomy-supportive environments, students will be more likely to retain their natural interest and curiosity and develop self-determined forms of regulation (Deci et al., 1991). Although each teacher's motivational style is different, teachers can tend either towards controlling or autonomy-supportive behaviors. Reeve (2016) illustrates controlling teachers using the following example:

> The teacher is insistent about what students should think, feel, and do, and the tone that surrounds these prescriptions is one of pressure. Implicitly, the teacher says, "I am your boss; I will monitor you; I am here to socialize and change you."
>
> Reeve contrasts controlling teachers with those who support students' autonomy:
>
> The teacher is highly respectful of students perspectives and initiatives, and the tone is one of understanding. Implicitly, the teacher says "I am your ally; I will help you; I am here to support you and your strivings."

Controlling teachers underutilize or undermine students' intrinsic motivation by failing to leverage their inner motivational resources (Reeve, 2009). Students in classrooms with more autonomy support display more intrinsic motivation, perceived competence, and self-esteem than students in more teacher-controlling environments (Deci et al., 1981). A study by Vallerand (1991) on high school students connected student perceptions of autonomy support with more self-determined forms of motivation (i.e. intrinsic motivation, identified regulation) and student perceptions of teacher controllingness with more non-self-determined forms (i.e. external regulation, amotivation).

Deci and colleagues (1994) suggest three interpersonal conditions that promote autonomy: 1) providing a meaningful rationale, 2) acknowledging negative feelings of the participant 3) using non-controlling language. The authors showed that free choice engagement with an activity occurred more when more contextual autonomy support was provided (Deci et al., 1994). In addition, engagement with the activity was more correlated with perceived choice, usefulness, and interest in conditions supporting self-determination compared with conditions not supporting self-determination. However, this research assessed a relatively uninteresting activity. To address interesting activities and those with personal meaning, Assor et al. (2002) added three more conditions to the operational definition of autonomy support: perspective taking, nurturing inner motivational resources, and displaying patience (i.e. allowing students to work at their own pace). Reeve and Cheon (2014) synthesized these and other studies into six mutually supportive autonomy-promoting instructional behaviors:

> "1) take the student's perspective; 2) vitalize inner motivational resources; 3) provide explanatory rationales for requests; 4) acknowledge and accept students' expressions of negative affect; 5) rely on informational, non-pressuring language; and 6) display patience."

Institutional factors may also affect perceived autonomy support. According to DeCharms (1976), teachers can learn to be more autonomy-supportive through training. School or university policies can also influence teachers' behavior. Deci and colleages (1982) suggested that teachers who feel controlled by their superiors are more likely to use controlling behaviors with their students. Flink, Boggiano, and Barrett (1990) showed that teachers who were more pressured by their administrators became more controlling relative to a control group of non-pressured teachers. In the more controlling classrooms, students performed less well in problem-solving activities. Thus, institutional culture can act indirectly to support or undermine students' perceived autonomy and motivation.

1.3.2 Contextual Support of Competence

Students with greater academic competence beliefs are more likely to use metacognitive strategies, persist through setbacks, seek out challenging courses, and achieve (Linnenbrink-Garcia et al., 2016). Educational environments can either support or thwart competence beliefs. Competence-supportive environments encourage students to set realistic goals (Locke & Latham, 2002), provide encouragement and positive feedback (Vallerand & Reid, 1988), or draw upon students' prior knowledge (Harter, 1978).

Providing students feedback is vital to learning. However, the means in which feedback is delivered can affect student motivation. Vallerand (1984) showed that students had higher levels of intrinsic motivation after receiving positive than negative feedback. Reid (1988) used path analyses to demonstrate that the changes in intrinsic motivation were mediated by changes in perceived competence. Lavigne, Vallerand and Miquelon (2007) found that teacher support of competence positively predicted student perceptions of competence and in turn supported students' science persistence intentions.

1.3.3 Contextual Support of Relatedness

Many studies have connected relatedness with internalization of motivation, although it may play a more distal role in creating intrinsic motivation compared with competence and autonomy (Deci & Ryan, 1980). In a study by Ryan, Stiller, and Lynch (1994) children who felt more securely cared for by their teachers more fully internalized regulation for positive academic behaviors related to engagement and coping. As Deci and Ryan (1991) point out, values and practices are more likely to be integrated when conveyed by adults to whom one feels positively related.

Ambient support for relatedness can also support internalization processes. Niemec and Ryan (2009) explain that "people tend to internalize and accept as their own the values and practices of those to whom they feel, or want to feel, connected, and from contexts in which they experience a sense of belonging." Extrinsically motivated behaviors are not typically interesting, so often they are initially performed after being prompted or valued by role models or those to whom one wants to feel related (Ryan, 2000).

Strategies for enhancing relatedness include conveying a sense of respect, caring, and warmth, to students (Niemec & Ryan, 2009). In practice, relatedness support has been demonstrated to facilitate internalization in many settings. For example, Ryan, Stiller, and Lynch (1994) demonstrated that elementary students who felt more securely connected to their teachers had more fully internalized motivation for positive academic behaviors.

1.3.4 Intrinsic Motivation and Positive Emotions

Intrinsic motivation is an attractive target for educational interventions not only because it is associated with performance and well-being, but also because it functions reflexively: building through repeated experiences (Ryan & Deci, 1985). It is well-documented that performing intrinsically motivated activities tends to produce positive emotions (Ryan, Huta, & Deci, 2008; Csikszentmihalyi, 1990). Recently, Lovoll and colleagues (2017) suggested that situational experiences of positive emotions in turn facilitate the development of intrinsic motivation. Idealistically, the experience of burgeoning intrinsic motivation is a state of flow—in which the individual experiences complete absorption with a task at the limits of their capability (Csikszentmihalyi, 2000).

The experience of enjoyment, focused attention, and deep engagement that characterizes intrinsic motivation is closely associated with the experience of interest. Indeed, Renninger (2000) suggests that interest and intrinsic motivation appear to describe similar outcomes. Advancing a step further, Krapp (2002) equates individual interest in a subject with an intrinsic motivational orientation. At present, the precise nature of the relationship between interest and intrinsic motivation is surrounded by theoretical discord. Schiefele (2001) suggests that interest is a precondition for intrinsic motivation. In contrast, Krapp (2002) describes interest as an outcome of the cognitive realization of basic psychological needs fulfilment. Fruitless efforts to disentangle causal mechanisms underlying interest and intrinsic motivation illustrate the close relatedness of these constructs as presently defined.

In their influential four phase model of interest development, Hidi and Renninger (2006) adopt an intermediate position, suggesting that interest and motivation interact reciprocally. Although they acknowledge the role of basic psychological needs in enhancing positive affect and contributing to interest development, they argue that felt competence, autonomy, and relatedness are not the only factors involved in interest development (Hidi & Renninger, 2006). Interest, they argue, also includes certain task value components (e.g., utility value, attainment value). As interest develops, its conative components take on greater importance.

1.4 Theoretical Perspectives on Interest

Interest is an important motivational variable: an emotion that motivates learning and exploration (Silvia, 2008). Functional approaches to emotion suggest that the role of interest is to ensure people will develop a broad range of skills and experience (Lazarus, 1991). Interest-driven, intrinsically motivated learning appears to support development beginning in infancy. Infants engage in a variety of playful, exploratory experiences that lead to important motor and perceptual learning (Fiske & Maddi, 1961). As learners age, interest causes them to use more deep learning strategies, persist longer at learning tasks, and perform better in courses (Schiefele, 2001).

Early researchers attributed interest to objective features of events or objects such as novelty, complexity, uncertainty, or incongruity (Berlyne, 1960). Modern theorists updated these ideas to suggest that interest instead stems from subjective appraisals of objects or situations (Silvia, 2006). Basing interest on interpretations rather than objective reality more appropriately accounts for variability due to personal and contextual influences, they argue. For example, people with different values or in different emotional states may experience varying levels of interest when prompted with the same stimuli (Schraw, 2001). Appraisal theories suggest that events or objects judged to be novel, complex, and comprehensible are more likely to be interesting (Silvia, 2005; Silvia, 2006).

As with intrinsic motivation, prominent theories suggest that interest develops through internalization processes. It begins as triggered situational interest – a psychological state predominantly determined by instructional conditions or the learning environment (Hidi & Renninger, 2006). As interest develops, it becomes more trait-like and rooted in values. The stable predisposition to re-engage with a particular content is known as individual interest (Renninger, 2000). Hidi and Renninger (2006) proposed that interest proceeds through four phases of development: progressing from triggered situational interest, to maintained situational interest, to emerging individual interest, to well-developed individual interest. Whether situational or individual, interest is always motivating (Renninger, 1990; 2000).

1.5 Research on Motivation and Interest in STEM

As policy and education reports implicate attrition and underperformance in STEM undergraduate study as contributors to STEM workforce and STEM literacy concerns, research has proliferated on interest and motivation in STEM fields (Wentzel & Wigfield, 2007). Education research has considered these topics from a variety of theoretical perspectives. In recent decades, self-determination theory and interest theory have been prominent positions. Volumes of research have documented motivation and interest through descriptive, observational, correlational, theoretical, and empirical studies (Lazowski & Hulleman, 2015)

Many studies have demonstrated links between early educational experiences and motivation to pursue careers or future study in STEM fields (Wang and Eccles, 2013). Experiences during high school and college appear particularly formative. Tyson et al. (2007) associated more rigorous high school coursework with more positive STEM outcomes in college. Maltese and Tai (2011) showed that personal goals during high school strongly predicted STEM college degree attainment. Similarly, Maple and Stage (1991) showed that the intention to major in STEM in 10th grade was positively correlated with pursuing STEM pathways in college. In an early longitudinal study, Hilton and Lee (1988) investigated STEM motivation across adolescence. They concluded that high school was the time of greatest flux for STEM motivation, with many students gaining and many students losing motivation towards STEM fields. They further concluded that the greatest overall attrition from STEM occurred between graduating high school and undergraduate matriculation. As a consequence, a great deal of research has centered on designing interventions at these stages.

The apparent timeline of STEM motivation development has also led research to focus on introductory college courses (Harackiewicz, 2016). Although introductory courses are designed to serve as a gateway for students to formally enter study of STEM disciplines, they are often where students decide to discontinue STEM study (Gasiewski et al., 2012). Several studies have implicated uninspiring lecture-based teaching practices in reducing STEM motivation and interest (Graham et al., 2013). As a consequence, a great deal of recent research has focused on characterizing relationships between instructional practices and student motivation in introductory courses (Harackiewicz, 2016).

In certain studies, investigators attempt not only to study motivation and interest, but also to enhance these outcomes. Researchers have employed numerous approaches to enhancing STEM motivation, ranging from short-term intervention programs to curricular changes. Many studies document motivation interventions designed to enhance outcomes across academic domains. Lazowski and Hulleman (2015) reviewed motivational interventions across domains, concluding them to be generally effective at achieving desired outcomes. Rosenzweig and Wigfield (2016) were the first to review motivational interventions in STEM specifically, finding mixed effects among a variety of motivation interventions. The authors note the importance of studying motivation towards STEM fields separately, since there is much evidence that students' beliefs, values, and goals differ across domains (Wigfield et al., 2015).

Although many studies focus on improving student motivation and achievement through contextual supports (i.e. classroom variables), others have shown that certain instructional practices can be effective across a variety of educational settings (Rosenzweig & Wigfield, 2016). Broadly speaking, motivation interventions often include collaborative, contextualized, or hands-on approaches, since these appear to positively influence students' outcomes in STEM fields (Myers & Fouts, 1992).

In recent years, research and development has proliferated on integrated, contextualized STEM learning approaches (NAP, 2014). According to Tsupros (2008), integrated STEM learning is an "interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise…" Integrated STEM instruction transcends disciplines by contextualizing learning in real-world problems (Stubbs & Myers, 2015). Although integrated STEM learning approaches show potential for enhancing learning and motivation, relatively little work has examined integrated STEM instruction or defined appropriate contexts. The lack of research on integrated STEM instruction has hindered successful implementation of these types of approaches (Myers & Dyer, 2004).

In summary, a strong theoretical basis supports the potential for research on motivation and emotion to transform education: improving both experiences and outcomes (Linnenbrink-Garcia et al., 2016). Although a growing body of empirical research documents the effectiveness of motivationally and emotionally supportive instructional principles, much of these studies are based on single theoretical perspectives or are conducted outside of authentic classroom settings (Lazoski & Hulleman, 2015). Additional research is needed to understand the developmental, contextual, and synergistic factors shaping learner motivation and interest and determine best practices for successfully translating research-based approaches to practice.

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PART I

The first part of this thesis examines interest and motivation in an introductory animal sciences course. Like many other introductory college courses, it had previously been taught through primarily traditional, didactic methods (i.e. lecture). The following chapters describe active learning strategies added to the course in the fall 2017 and subsequent semesters with the goal of improving student interest, motivation, and performance. Chapter Two summarizes student impressions of the entire suite of learning activities added to the course, while Chapter Three focuses on comparing two specific problem-based learning strategies with lecture instruction. Together, these studies characterize effective activities in our course by profiling situational and individual changes to student motivation and interest.

CHAPTER 2. CREATING INTEREST THROUGH ACTIVE LEARNING IN AN INTRODUCTORY ANIMAL SCIENCE COURSE

2.1 Introduction

Stimulating and maintaining student interest is a primary goal of college education, since the level of interest in one's chosen area of study can impact both educational performance and well-being outcomes (Schiefele 1992). Stronger interest has been shown to increase students' motivation to seek knowledge and the number of strategies they employ toward learning (Pressley et al 1992). In higher education courses, the structure of course activities and the learning environment in which they are administered can greatly influence students' curiosity in a subject. Consequently, administrators and instructors can attempt to improve subject interest by restructuring courses and the classroom environment.

Classroom interventions designed to increase student interest often target introductory courses composed primarily of first-year students, aiming to influence students' entire college career. One frequently-used strategy is the addition of active learning elements (Yuretich 2001, Freeman 2014). Previous research has posited a positive feedback loop between subject-specific curiosity and active learning (Stahl and Feigenson, 2015). Implementation of active learning through social, authentic, problem-based activities develops student interest and motivation by supporting needs for autonomy and relatedness (Deci, 1992). Active learning can be implemented through many strategies, each with differing effects on student learning and interest. Relatively little is known about the types of activities and features of learning environments that best support the development of student interest (Rotgans, 2010).

Active learning and interest have not been studied extensively in agriculture courses. However, there is potential for improving interest through adding active learning in these courses. Garton's study of learning preferences indicated that agriculture students favored cooperative, interactive learning environments (Garton, 1997). Kansas State University agriculture students described "an enthusiastic and interesting teaching style" and "an interactive classroom environment" as the classroom characteristics that most motivated them to learn, and selected "a long, boring lecture" as the primary factor in reducing motivation (Mankin et al., 2001).

Constructivist learning theory dictates that motivation is key to learning (Palmer, 2005). Interest has been recognized as a component of motivation by many studies on academic motivation and performance (Rotgans, 2011b; Wagner, 2012). Recent work has shown that interest can lead to higher task involvement, improved learning, and increased academic achievement (Harackiewicz, 2016).

Interest theories generally characterize interest as consisting of two forms: situational interest and individual interest (Hidi, 1990). Situational interest refers to a transitory psychological state triggered by external factors, whereas individual interest is a more enduring disposition shaped by personal values and experience (Zhu, 2009). Increased situational interest in tasks precedes the development of individual interest in subjects.

Promoting interest of either form can improve learning by increasing engagement and motivation. Interest is especially important in active learning classrooms, which are characterized by self-initiated, collaborative, and problem-based learning activities (Schmidt, 1993). Classrooms that promote learner autonomy and relatedness among students are beneficial to student interest (Deci, 1992). Active learning strategies including authentic, problem-based learning increase perceived meaning and task-value, supporting student interest (Rotgans, 2011b).

To address these student needs, many departments within colleges of agricultures have declared a focus on interactive, experiential, or hands-on learning as core elements of their strategic plan. The objective of this research was to study the effects of these strategies. This study examines student interest in animal sciences and the effects of active learning updates implemented in an introductory, required course, traditionally taught through lecture-based techniques.

2.2 Purpose and Objectives

The purpose of this study was to explore and describe the relationships between student interest in animal sciences and active learning strategies during an introductory course. The following objectives guided this research:

1. Evaluate students' perceived level of interest in animal sciences at the beginning and end of the semester.
2. Examine students' perceptions of the efficacy of seven newly-implemented active learning strategies on increasing their interest.
3. Investigate relationships between self-rated level of interest in animal sciences and the perceived impact of learning activities on interest.

2.3 Materials and Methods

All experimental procedures were approved by the Purdue University Institutional Review Board. This study assessed 238 students enrolled in an introduction to animal agriculture course in the fall 2017 semester. This sixteen-week course consisted of twice weekly 50-minute lectures and a weekly 110-minute laboratory session. Course materials covered the following animal production topics: nutrition, reproduction, global issues, industry trends, welfare, health management, breed identification. Species discussed ranged from livestock to companion animal to zoo animal.

Active learning additions made for fall 2017 are summarized in Table 1. For the lecture portion of the course, clicker questions, think-pair-share activities, case studies, and exam review sessions comprised the active learning update. We revised course laboratories to include activity stations, handouts, and critical reflections. Since the course was primarily composed of first-year animal sciences majors, we added these active learning elements with the goal of supporting desired departmental outcomes of increased student performance, retention rates, and improved interest in the subject.

Table 2.1 List of active learning additions incorporated in fall 2017 Introduction to Animal Agriculture.

Lecture	Laboratory
Case studies	Stations
Think-pair-share	Handouts
Exam review sessions	Critical Reflections
iClicker questions	

The course held lectures in a traditional lecture hall with front-facing, tiered seating. Two to three iClicker questions asked during lecture presentations verified student understanding of the course materials. The instructor periodically asked students to work with a partner for brief, 5-minute Think-Pair-Share activities on questions related to the day's content. For each species unit, students completed 20-minute case studies in groups of 4 to 6 assigned at the beginning of the semester.

Laboratories took place on campus in the university's Animal Sciences Teaching Laboratory, the off-campus Animal Sciences Research and Education Center, and private animal facilities. Laboratories consisted of four to five stations with activities related to the subject matter.

Undergraduate laboratory teaching assistants, the class instructor, and subject experts guided students through each station activity. Instructors encouraged students to move around in groups to complete station activities and fill in a lab handout, and facilitated rotating student groups once each activity was finished.

2.3.1 Questionnaire Design

We developed a questionnaire to assess demographics, self-rated curiosity levels, and views toward the learning activities. The post-questionnaire utilized a total of 12 questions including Likert-scale, anchored scale, multiple choice, and open-ended questions. We administered the post-questionnaire electronically via Qualtrics to students during the last week of the course. 222 of 238 students provided responses (93.2%). The questionnaire required completion of each question before advancing. We derived demographic information including gender, major, transfer status, ethnicity, and semester classification from course enrollment records. In addition, we collected demographic information related to the students' background in agriculture. This included previous experience with 4-H/FFA, hours of contact with each species, parent involvement in agriculture, and high school agriculture coursework.

2.3.2 Statistical Analysis

We used SPSS software for all statistical analyses (SPSS 22.0, SPSS, Chicago, IL) To compare levels of curiosity at the beginning and end of the course, we used paired t-tests. We assessed correlations between curiosity levels and the perceived impact of each of the learning activities on interest through Pearson correlation coefficients. We interpreted correlation absolute values as follows: $r = 0.00$ to 0.19, very weak; 0.20 to 0.39, weak; 0.40 to 0.59, moderate; 0.60 to 0.79, strong; 0.80 to 1.0, very strong. For each of analysis, we converted verbal Likert and anchored scales to numerical values 1 to 5. We declared statistical significance at $p < 0.05$.

2.4 Results

2.4.1 Demographics

Table 2 summarizes course demographic information and reflects the 222 survey respondents. The class was composed primarily of females (79.3%, $n = 176$) and was predominantly first-year students (75.7% freshmen, $n = 168$). The majority of students were from majors within the College of Agriculture and were not transfer students. Students enrolled in pre-veterinary medicine degree or concentration made up 62.6% of all respondents (n = 139). Of animal science majors, 82.5% identified themselves as pre-veterinary medicine concentration (n=113). Students most frequently selected "companion animal" as their primary species of interest, and many students reported having significant experience with companion animal species within the past five years. As a whole, students had no or minimal recent experience with food animal species and came from mostly non-farm backgrounds (64.4%). Students did report having previous agriculture experience through high school coursework (51.9%), 4-H (38.4%), or FFA (25.9%).

Table 2.2. Demographics of students enrolled in fall 2017 Introduction to Animal Agriculture. (n=222)

Gender	#	%
Female	176	79.3
Male	46	20.7
Classification	#	%
Freshman	168	75.7
Sophomore	49	22.1
Junior	4	1.8
Senior	1	0.4
Major	#	%
Animal Sciences	137	61.7
Other agriculture	56	25.2
Non-agriculture	29	13.1
Hometown	#	%
Rural, farm	79	36
Rural, non-farm	61	27
Urban	28	13
Suburban	54	24
Total Respondents	222	100

2.4.2 Interest in Animal Sciences

Student self-rated curiosity in animal sciences is summarized in Table 3. Students rated themselves highly curious prior to their experience in the course, with 67.3% selecting levels of "extreme (5)" or "very much (4)" to describe their level of curiosity in animal sciences when asked to select their level on an anchored scale (not at all – 1, slight – 2, moderate – 3, very much – 4, extreme – 5). When rating their level of curiosity at the end of the course, 65.3% of students selected the two highest ratings. Paired t-tests indicated no significant change in self-rated level of curiosity over the course of the semester.

Table 2.3. Student self-rated level of curiosity in animal sciences prior to and following the course. (n=222)

	Not at all		*Slight*		*Moderate*		*Very Much*		*Extreme*		*Total*	
	#	%	#	%	#	%	#	%	#	%	#	%
Pre-Course	3	1.35%	12	5.41%	62	27.93%	95	42.79%	56	22.52%	222	100%
Post-Course	2	0.90%	8	3.60%	63	28.38%	93	41.89%	50	25.23%	222	100%

Table 2.4. Students' self-rating of the impact of each of the learning activities on their interest in studying animal sciences.

	Strong Negative Impact		Negative Impact		Neutral		Positive Impact		Strong Positive Impact		Total
Activity	#	%	#	%	#	%	#	%	#	%	#
Case Studies	3	1.35	24	10.76	111	49.78	73	32.74	12	5.38	222
Think-Pair-Share	2	0.9	11	4.93	103	46.19	95	42.6	12	5.38	222
Exam Review Sessions	3	1.35	7	3.14	113	50.67	66	29.6	34	15.25	222
iClickers	2	0.9	5	2.24	93	41.7	101	45.29	22	9.87	222
Laboratory Stations	1	0.45	7	3.14	39	17.49	134	60.09	42	18.83	222
Laboratory Handouts	4	1.79	17	7.62	85	38.12	98	43.95	19	8.52	222
Laboratory Critical Reflections	10	4.48	27	12.11	102	45.74	66	29.6	18	8.07	222

2.4.3 Relationships between curiosity level and impact of learning activities on interest

Post-course curiosity levels were positively correlated with all of the activities' impact on interest (Table 5). Of the active learning strategies assessed, case studies, think-pair-share, and laboratory stations were most correlated with student curiosity levels, with Pearson correlation coefficients of 0.373 (p <0.0001), 0.329 (p <0.0001), and 0.377 (p <0.0001) respectively, indicating weak positive relationships.

Table 2.5. Correlations between post-course curiosity and the impact of each learning activity on interest in studying animal sciences.

Activity	Pearson correlation coefficient	p-value
Case Studies	0.37265	<0.0001
Think Pair Share	0.32889	<0.0001
Exam Review Sessions	0.16205	0.0157
iClickers	0.19295	0.0039
Lab Stations	0.37725	<0.0001
Lab Handouts	0.25573	0.0001
Critical Reflections	0.19236	0.0040

2.4.4 Differences in curiosity levels across majors

Students' curiosity in animal sciences did not differ between pre- and post-course ratings for students majoring in animal sciences, other college of agriculture majors, and non-agriculture majors (Table 6). However, for both pre-course and post-course ratings, animal science majors had significantly higher curiosity levels when compared with other college of agriculture majors and non-agriculture majors (Table 7).

Table 2.6. Mean self-rated curiosity levels (not at all – 1, slight – 2, moderate – 3, very much – 4, extreme – 5) of students majoring in animal sciences, other college of agriculture (CoA) majors, and non-agriculture (non-CoA) majors, and t-test comparison of means for pre-course vs. post-course (n = 223).

Major	# Students	Pre-course	Post-course	t statistic	p-value
Animal Sciences	137	4.02	3.97	0.76	0.22
Other CoA	57	3.68	3.59	0.90	0.19
Non-CoA	28	3.52	3.37	0.89	0.19
All	222	3.62	3.51	1.26	0.11

Table 2.7. T-test comparisons between mean self-rated curiosity levels (not at all – 1, slight – 2, moderate – 3, very much – 4, extreme – 5) of students majoring in animal sciences, other college of agriculture (CoA) majors, and non-agriculture (non-CoA) majors.

	Pre-course			Post-course		
	means	t	p-value	means	t	p-value
Animal Sciences vs. Other CoA	4.02 vs. 3.68	2.54	<0.01	3.97 vs. 3.59	2.72	<0.01
Animal Sciences vs. Non-CoA	4.02 vs 3.52	2.97	<0.01	3.97 vs. 3.37	3.35	<0.001

2.5 Discussion

This study examined interest in students in an introductory animal sciences course, and considered self-rated curiosity in the subject as a measure of individual interest. Although a generalized individual interest inventory was recently validated by Rotgans (2015), we chose to operationalize individual interest through self-assessment questionnaires specific to our context, similar to Dotterer et al. (2009) and Kalender and Berberoglu (2009).

All of the active learning strategies assessed (case studies, think-pair-share, exam review sessions, iClicker questions, laboratory stations, laboratory handouts, laboratory critical reflections) had positive impacts on interest in studying animal sciences for the students we assessed. Of these activities, students viewed laboratory stations as the most beneficial to their interest.

Laboratory stations incorporated authentic, problem-based, and collaborative learning to a greater degree than other activities, which may be responsible for the larger positive effect on interest compared with other activities. During laboratory stations, students rotated to tables in groups of six to eight and were assisted by experts to complete hands-on activities and fill in laboratory handouts. Activities included simulating management techniques, labeling anatomy, and completing short case studies using information and objects provided.

We found weak correlations between post-course curiosity and the impact of learning activities on interest in studying animal sciences. This would suggest that students with more individual interest in animal sciences benefit more from active learning activities. This is supported by Rotgans et al. (2015) where individual interest was found to be a significant predictor of cognitive engagement in problem-based learning environments. Increased cognitive engagement with learning tasks has the further positive effect of increasing how much is learned from these activities (Rotgans, 2011a).

Students in our study rated themselves as highly interested in studying animal sciences both prior to and following the semester-long course, and no change was observed over the course of the semester. This is corroborated by previous work suggesting individual interest is relatively stable (Rotgans, 2011b).

Self-rated curiosity in studying animal sciences was significantly higher in animal sciences majors compared with other college of agriculture majors and students from outside the college of agriculture. Selection of animal sciences as a major could be assumed to indicate existing interest in the subject or prior knowledge and experience, which Schraw and Lehman conclude is positively related to individual interest (Schraw, 2001).

Understanding student interests may become increasingly relevant to animal sciences departments as student demographics continue to change. In recent decades, animal science courses have tended towards student profiles similar to that observed in the present study: predominantly female, interested in veterinary medicine, from urban or suburban backgrounds, and having relatively little livestock knowledge or experience (Peffer 2011).

A large proportion of our students had significant past experience with companion animals, but very few had prior background with food animal species. Companion animals were most frequently selected by students as the primary species of interest. McNamara (2009) suggests animal science students are inclined to be more interested in species more familiar to them. As the number of Americans directly involved with agriculture declines, the number of undergraduates entering animal science programs with prior livestock experience is also decreasing (Buchanan, 2008).

Only a small fraction of students expressed interest in food animal species in our study, and very few had past experience with livestock species. Comparable past studies highlight a trend toward lower interest in food animal species among animal science students (Peffer, 2001; Reiling, 2003; Edwards, 1986). Peffer suggests that this student profile may be problematic because it does not align with workforce needs. Interests are recognized as a primary driver behind career choices and performance (Lent, 1994). As McNamara (2009) notes, to remain relevant, academic programs must adapt to employment trends and student needs.

Creating more student interest in food animal species is a realistic goal for introductory animal science courses. Students in Peffer's study with low initial interest in food animal species selected livestock species as the most beneficial of species learned upon completion of a 10-week introduction to animal sciences course. This could indicate that interest in previously unfamiliar species can be developed through exposure in similar courses. Changes to interest specific to species may be an important topic for future research.

2.6 Summary

Overall, students in this introductory course rated themselves as highly interested in studying animal sciences, and viewed all the active learning strategies implemented as further increasing their interest. Of the learning strategies assessed, students favored the collaborative, problem-based laboratory station activities. These results may inform creation of instructional strategies that support the development of student individual interest. In active learning settings, individual interest can lead to greater cognitive engagement and durable learning.

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CHAPTER 3. CHARACTERIZING STUDENT ENGAGEMENT WITH HANDS-ON, PROBLEM-BASED, AND LECTURE ACTIVITIES IN AN INTRODUCTORY COLLEGE COURSE

3.1 Introduction

A growing number of studies show that active instructional methods may more effectively support student interest, motivation, and achievement compared with passive methods such as lecture (Blumenfield, Kempler, & Kracjik, 2006; Freeman et al., 2014). Active instruction may be particularly impactful when implemented in introductory college courses (Harackiewicz, 2000). Introductory college courses, many of which are large enrollment, have traditionally been taught through lecture-based methods (Deslauriers, Schelew & Wieman, 2011). However, as active instructional methods gain acceptance in higher education, many studies have documented their benefits on interest, motivation, and performance of learners in introductory courses (Yuretich, Khan, Leckie, & Clement, 2011; Deslauriers et al., 2011; Drinkwater et al., 2014).

The recent proliferation of research on active learning, however, has left important questions unanswered (Bernstein, 2018). For example, the predominant focus on connecting instructional techniques with performance outcomes has blurred distinctions between active teaching and active learning (Chi & Wylie, 2014). Active learning does not constitute the implementation of certain instructional practices. Rather, it denotes learners' meaningful cognitive and emotional engagement in the learning process, which instructors facilitate through specific techniques (Prince, 2004).

Still, active instruction encompasses a wide variety of educational methods (Bonwell & Eison, 1991), and there is little empirical research describing specific course activities involved in promoting active learning in the college classroom (Wainwright, 2013; Rowles, 2013). Research that does assess specific course activities tends to consider unitary activity types—obscuring substantial variation in instructional design, content, and implementation (Bernstein, 2018). Further, relatively little research has examined underlying cognitive and emotional processes that may mediate the effects of active learning on performance outcomes (Daniel & Poole, 2009).
The present study answers the call by Bernstein and other scholars of teaching and learning for a "second generation" of active learning research involving deeper, more specific study of defined instructional methods and the underlying processes associated with their benefits (Bernstein et al.,

2018; Daniel and Poole, 2009; Freeman et al., 2014). In it, we examine student interest and motivation in an introduction to animal sciences course relative to three specific instructional techniques: video lectures, case studies, and laboratory stations. These activities represent a cross-section of the course following an active learning redesign, in which interactive components (i.e. case studies and laboratory stations) were added to supplement the course's traditional lecture-based instruction. This study seeks to characterize students' interest and motivation in the active and passive instructional strategies comprising the course.

3.2 THEORETICAL FRAMEWORK

Our investigation of learners' experience with three instructional strategies is based in a dynamic systems perspective of achievement behavior (Lewis & Granic, 2000). Within this framework, cognitive, affective, and behavioral reactions to specific learning situations reflect interactions between the immediate experience and crystallized existing schema (Ainley, 2012). More specifically, the experience of meaningful engagement that characterizes active learning (or conversely, the experience of disaffection) arises from person-environment interactions and functions within a self-organizing system of psychological processes (Izard, 2007).

3.2.1 Engagement

Although we acknowledge that learners' immediate classroom experience is embedded within layers of more general contexts, the present study focuses on the microsystem associated with a discrete learning task (Bronfenbrenner, 1992). At this level, task engagement is conceptualized as the connection between person and activity on cognitive, affective, and behavioral dimensions (Russell et al., 2005). In addition to measuring behavioral engagement, we further consider learners' motivation and interest—important underlying processes that function to connect learners to tasks (Ainley, 2012).

3.2.2 Motivation

While engagement refers to actualized involvement with a task, motivation is the underlying psychological process activating and directing behavior. Russell and colleagues (2005) clarify: "motivation is about energy and direction, the reasons for behavior, why we do what we do. Engagement describes energy in action." Motivation exists in several forms, each varying in function (Deci & Ryan, 1985). Intrinsically motivated behavior involves pursuing activities for their inherent satisfaction. In contrast, extrinsically motivated behavior is driven by outcomes separate from the activity (Deci & Ryan, 2000). In their influential self-determination theory, Deci and Ryan further set forth several types of extrinsic motivation based on the individual's internalization of the activity's value. Extrinsic motivation, according to the authors, can exist as external regulation, introjected regulation, identified regulation, and integrated regulation (Deci & Ryan, 2000). In education settings, important functional differences exist along Deci and Ryan's motivation continuum. Students with greater levels of internalized, self-determined motivation (e.g. intrinsic motivation, identified regulation) tend to exhibit enhanced performance, persistence, and creativity (Deci & Ryan, 2000), greater satisfaction, more positive emotions, and more enjoyment in their academic work (Vallerand, 1988). Conversely, amotivation in the classroom (i.e. behavior disconnected from values and interests) is associated with poor academic performance and reduced well-being (Deci & Ryan, 2000).

At the course level, several studies have shown that students experience greater intrinsic motivation when they perceive instructors as supportive of students actively engaging in the learning process (Black & Deci, 2000; Guay, Boggiano, & Blanchard, 2001). Recent work has centered on the motivational effects of specific active learning strategies, particularly in higher education settings. Blumenfield and colleagues (2006) report that college classrooms using active learning principles such as inquiry, authenticity, and collaboration are more likely to be intrinsically motivating to students. Jeno et al. (2017) showed that team-based learning increased intrinsic motivation and identified regulation and decreased amotivation compared with lecture-based instruction for college students. Similarly, Serrano-Camara et al. reported higher levels of intrinsic motivation for college freshmen involved in collaborative learning activities compared with lecture (2014).

3.2.3 Interest

Interest, like motivation, is associated with learner engagement. Interest is a basic emotion that motivates learning and exploration (Silvia, 2008). It includes both cognitive and affective components (Hidi et al., 2004; Renninger & Hidi, 2011). In educational settings, interest precipitates academic engagement and achievement: promoting attention, persistence, and effort (Ainley, Hidi, & Berndorff, 2002; Hidi, 1990; Hidi & Renninger, 2006). However, like motivation, interest develops through internalization processes. Consequently, both intrinsic and extrinsic factors serve important functions in stimulating and holding interest (Hidi and Renninger, 2006).

Interest research has followed a similar but separate trajectory to motivation research. Interest is generally conceptualized as existing in two forms: situational and individual (Hidi & Renninger, 2006). Situational interest is the focused, attentive psychological state experienced in the moment and triggered by environmental stimuli (Krapp, Hidi, & Renninger, 1992). In contrast, individual interest refers to a relatively stable trait-like predisposition to reengage with a particular content and signifies deepening knowledge and value of the subject area (Renninger, 2000, p373). Our study focuses on situational interest processes associated with specific learning tasks.

Situational interest can be triggered by features of the learning environment or task, or represent actualized individual interest in a particular content area (Hidi and Renninger, 2006). Anecdotally, educators report using a wide variety of tactics to stimulate and hold interest. Text- and task-based factors such as coherence (Schraw et al., 1995), relevance (Schraw & Dennison, 1994), and vividness (Kintsch, 1980) tend to be associated with greater situational interest. Hidi and Renninger suggest that people are more interested in tasks perceived as meaningful (2006). The study of interest may be particularly relevant in active learning contexts (Rotgans, 2011). There is evidence that problem-based, collaborative, and hands-on approaches enhance interest (Gokhale, 1995; Holstermann, 2010; Rotgans, 2011). However, situational interest has predominantly been studied under controlled, laboratory settings. The actualization of interest in the context of real learning activities or within classroom settings is poorly understood (Bergin, 1999; Jetton & Alexander, 2001; Rotgans, 2011).

3.3 The Present Study

We hypothesized that the quality of students' experience would differ for different instructional formats, resulting in differing manifestations of situational interest, intrinsic motivation, and behavioral engagement (Krapp, 2005). For experimental treatments, we selected three learning activities representing a cross-section of both the passive and active methods used in the course. In addition to lecture instruction, the course includes activities using problem-based and hands-on learning. Problem-based learning is an active instructional model in which learners work in groups to research solutions for an authentic problem (Jonassen & Hung, 2008). In our course, problem-based learning is implemented with small group lecture-based cases (Barrows, 1986). In course laboratories, case-based scenarios are extended to include hands-on learning components. We define hands-on activities as those that allow students to interact with real physical objects related to the content to discover information or perform tasks.

3.4 Purpose

The purpose of this study was to examine interest, motivation, and engagement of students involved in passive and active instructional techniques during an introductory animal science course. Our study was guided by the following questions:

1. How do video lecture, laboratory station, and case study activities affect students' situational motivation and situational interest?
2. How do video lecture, laboratory station, and case study activities affect students' behavioral engagement?

3.5 Method

3.5.1 Participants and Context

This study involved a convenience sample of 178 students enrolled in an introduction to animal agriculture course during the fall 2018 semester. This 16-week course consists of twice weekly 50-minute lectures and a weekly 110-minute laboratory session. Laboratories were divided into five sections of 35 to 45 students each. The course is required for the Animal Sciences major, and primarily composed of first-year students (42.70%, n = 76) and females (86.52%, n = 154). The majority of students had no or minimal experience with livestock species, with 87.79% of the class reporting less than 20 hours experience in the last five years (n = 151). Historically, the course was taught using primarily traditional, passive learning methods. In the fall 2017 semester, the course was remodeled to reflect a more active, learner-centered approach (Erickson, Guberman, & Karcher, in press). Active instructional updates included changes to both course lectures and laboratories. For the lecture portion of the course, clicker questions, think-pair-share activities, and case studies comprised the active learning update. Course laboratories were revised to include stations with hands-on activities. These active learning techniques were added to support departmental goals to increase student interest in the subject and improve performance and retention.

3.5.2 Study Design

All procedures for this study were approved by the Institutional Review Board. This quantitative experiment assess three types of learning activities. Table 1 describes the standard procedures for course activities used as treatments.

Table 3.1. Summary of instructional formats used as experimental treatments.

Treatment	Description	Characteristics
Video Lecture	Learners watch lecture slides and listen to audio voiceover of the instructor describing concepts. Learners may or may not take notes. Minimal interactions occur between group members.	Lecture
Case Study	Using a packet of reference materials, learners work through a realistic written case study. Group members discuss the problem and provide verbal evidence of their viewpoints. The group must agree on a consensus and justify their choices in brief written responses (approx. 3-5 sentences) to case scenario prompts. Course instructors are available to answer questions but provide minimal guidance throughout the process.	Problem-based case study
Lab Station	Using a packet of reference materials, learners work through a realistic written case. In addition to discussing the problem in their group, learners must discover evidence by observing or completing tasks with physical objects related to the problem scenario. The group must agree on a consensus and justify their choices in brief written responses (approx. 3-5 sentences) to case scenario prompts. Course instructors are available to answer questions but provide minimal guidance throughout the process.	Hands-on, problem-based case study

We completed the experiment during three of the course's weekly laboratory sessions, during weeks seven, nine, and ten of the semester. Each experiment day was considered an experimental period. For each period, the course's five laboratory sections were each split into three treatment groups and each assigned two groups of five to seven students. During each laboratory, students completed the assigned experimental activity and survey before moving on to normal course activities. One experimental period therefore consisted of five repetitions conducted over an experiment day with students from each of the five course laboratory sections.

Treatments were assigned using the Latin Square arrangement summarized in Table 2. In each experimental period, content and learning objectives were standardized across the video lecture, laboratory station, and case study activities. In addition, content was delivered using the same text and pictures across activities, provided to students either through lecture slides or as supporting materials for case-based activities. Content and learning objectives were varied for each repetition to prevent prior exposure to the material from confounding results and to control for interactions between content and instructional format. However, for each experimental period, text and pictures were nearly identical between video lecture, laboratory station, and case study activities to prevent factors other than the delivery format from influencing students' situational experience (Rotgans, 2011).

For each experimental period, we recorded all groups of students on video, and collected completed handouts. We used the artifacts and recorded video to confirm that students engaged with each activity in the manner intended (i.e. hands-on learning, problem-based learning).

Table 3.2. Randomly-assigned treatments were rotated in a Latin square arrangement. Experimental activities were repeated five times for each period.

Group #	Period 1 Week 7	Period 2 Week 9	Period 3 Week 10
1	Lecture	Case Study	Lab Station
2	Lab Station	Lecture	Case Study
3	Case Study	Lab Station	Lecture
4	Lecture	Case Study	Lab Station
5	Lab Station	Lecture	Case Study
6	Case Study	Lab Station	Lecture

3.5.3 Instrumentation

We chose self-report measures to quantify situational interest, situational motivation, and individual interest. Although motivational variables can be measured through both self-report and behavioral observation, self-report measures can provide more information about the nature and extent of interest and motivation (Renninger, 2011). Self-report questionnaires are appropriate for studies with large samples of participants or involving populations where the phenomena in question have not been well-documented (Fulmer and Frijters, 2009; Renninger, 2011). We constructed a questionnaire based upon previously-validated instruments for measuring situational interest, situational motivation, and individual interest.

Situational interest was measured using the Situational Interest Scale (SIS) developed by Chen and colleagues (1999) and shown in Appendix 1. Compared with the situational interest scale developed by Linnenbrink-Garcia et al. (2010) to measure interest at the course level, Chen et al.'s (1999) SIS is more suitable to learning activities and tasks. In addition, the SIS is grounded in Self-Determination Theory and addresses both the affective and task-value components of situational interest, making it compatible with our working conceptualizations of interest and motivation (Chen et al., 1999; Renninger and Hidi, 2011). Although developed for physical education, this scale has since been successfully adapted for a diverse range of educational experiences (Dan, 2010; Roberts, 2015). The Cronbach's alpha coefficient for our sample was 0.96, indicating excellent internal consistency of the measure (Tavakol, 2011).

We used the Individual Interest Questionnaire (IIQ) developed by Rotgans (2015) to measure individual interest. Compared with other measures including fewer items, the IIQ more adequately captures the broad definition of individual interest operationalized in this study: a multi-faceted construct including predisposition to re-engage, positive feelings, and increased value for the content (Rotgans, 2015; Sansone, 2000). The validity of the IIQ has been established in higher education settings for a range of content areas (Duchatelet, 2016; Rotgans and Schmidt, 2017; Rotgans and Schmidt, 2018). Cronbach's alpha coefficient was 0.86 for our sample, suggesting good reliability of the measure (Tavakol, 2011).

We measured situational motivation using using Guay, Vallerand, and Blanchard's (2000) Situational Motivation Scale (SIMS). To our knowledge, the SIMS is the only existing scale for the multi-dimensional assessment of intrinsic and extrinsic motivation at the situational level (Guay et al., 2000). The instrument's sensitivity made it well-suited to profile motivation for the closely-related experiences we chose as treatments. The SIMS is rooted in Self-Determination Theory and has been widely-used as a measure of academic motivation in college undergraduates (Kirby, 2015; Spence, 2014; Yu and Levesque-Bristol, 2018). Cronbach's alpha coefficients for the intrinsic motivation, identified regulation, external regulation, amotivation subscales of the SIMS were 0.99, 0.87, 0.85, and 0.88 respectively. This indicates good reliability of the measure with our data set (Tavakol, 2011).

We assigned completion grades to students involved in experimental activities rather than effort- or standards-based grades. This choice was made (1) to reflect the natural structure of the activities within our course and (2) to prevent external pressures from interfering with our study of motivation. In some studies, external rewards have been shown to undermine intrinsic motivation (e.g. Hewett & Conway, 2016). We decided that completion grades would prevent this undermining effect from interfering substantially with our study of intrinsic motivation.

3.5.4 Experimental Procedure

Course instructors and teaching assistants used the procedure that follows in each laboratory section across experimental periods. First, we divided students in each of the course's five laboratory sections into groups of five to seven students (n = 30) and seated students in each group around a table. Groups and table location remained constant across experimental periods. Students participated in the experiment for a total of 15 to 20 minutes at the beginning of each laboratory session. Then, we informed students that they would complete an activity and a survey and that their responses would not affect their grade. Next, we distributed instructional materials to each table. Finally, we told students they would have ten minutes to complete the activity and asked everyone to begin. For each experimental period, students completed the activity within 7 to 10 minutes. Immediately following activity completion, we administered the survey via Qualtrics (Qualtrics, Inc., Provo, UT). Students used laptops, tablets, or mobile phones to complete questionnaires, which required students to complete each item before advancing. Each experimental period, all students in attendance completed the activity and questionnaire. Of the students enrolled in the course, survey response rates were 97.2%, 93.8%, 92.3% for the first, second, and third experimental periods, respectively.

3.5.5 Behavioral Observation

We measured behavioral engagement through observation. During each experimental period, we recorded video of students completing assigned activities. Three trained observers rated student engagement in video recordings using the Behavioral Engagement Related to Instruction protocol (Lane 2015). Observers viewed 10-minute video segments beginning when students were presented with instructional materials and instructed to begin, recording student ratings at minutes 1:00, 3:00, and 5:00.

Observers were trained with sections of footage taken during the experimental day but not used for the project. During an initial training period, observer-trainees rated 15-minutes of video alongside a trained observer, discussing discrepancies after each rating. Next, observer-trainees rated 15-minutes of video independently, generating ratings for six timepoints. Each observer-trainee's ratings for this independent rating period were compared with the ratings of a trained observer. If a Cohen's kappa statistic greater than 0.70 was achieved, observers were considered adequately trained. If observer-trainees failed to rate in agreement enough to generate Cohen's kappa values greater than 0.70, they discussed discrepancies with the trained observer and entered remedial 15-minute independent rating sessions until adequate inter-rater reliability was established. Unweighted Cohen's kappa values exceeding 0.70 indicate substantial observer agreement (Landis & Koch, 1977). Cohen's kappa statistic is frequently used to test interrater reliability and is more robust than percent agreement because it accounts for chance agreement (McHugh, 2012).

3.5.6 Statistical Analyses

We completed all data analyses using SAS software (SAS Institute Inc., Cary, N.C.). Prior to analysis, we used the UNIVARIATE procedure to perform Shapiro-Wilk's normality test. For objective 1, we compared least squares means of treatment effects using the MIXED procedure of SAS, including experimental period as a repeated effect with SUBJECT=group. We selected compound symmetry as the covariance structure on the basis of best fit based on Schwarz's Bayesian Information Criteria (BIC). For objective 2, we accounted for non-normality and bounded support of behavioral engagement data by fitting a generalized linear mixed model using PROC GLIMMIX. Experimental group was included as a random effect. We tested fixed video observer and period effects and excluded them as non-significant. No data were excluded.

3.6 Results

Table 3 summarizes students' situational interest in each instructional format based on the Situational Interest Scale (SIS). Situational interest was highest for students completing laboratory stations, followed by case studies and video lectures, respectively. Students perceived laboratory stations as more challenging, novel, and attention-grabbing than video lectures and case studies.

Compared with video lectures, students rated laboratory stations and case studies higher in terms of instant enjoyment and exploration intention.

Table 3.3. Least squares means for animal science introductory course students across three experimental periods at weeks 7, 9, and 10 of the 16-week semester (n=501) of Situational Interest Scale (SIS) subscales and the overall scale average (Likert scale: 5 = strongly agree, 1 = strongly disagree). No significant difference (p > 0.05) was observed between treatments for values with the same superscript.

Situational Interest Scale	Video Lecture	Lab Station	Case Study
Exploration Intention	3.38[a]	3.76[b]	3.71[b]
Instant Enjoyment	2.71[a]	3.61[b]	3.44[b]
Novelty	2.50[a]	3.38[b]	2.80[c]
Attention Demand	2.74[a]	3.81[b]	3.51[c]
Challenge	1.82[a]	2.45[b]	2.15[c]
Total Interest	2.60[a]	3.58[b]	3.27[c]
Situational Interest	**2.63[a]**	**3.43[b]**	**3.15[c]**

Table 3.4. Least squares means for animal sciences introductory course students across three experimental periods at weeks 7, 9, and 10 of the 16-week semester (n=501) for the Situational Motivation Scale (SIMS) subscales (Anchored scale: 1 = corresponds not at all, 7 = corresponds exactly). No significant difference (p > 0.05) was observed between treatments for values with the same superscript.

Situational Motivation Scale	Video Lecture	Lab Station	Case Study
Intrinsic Motivation	3.38[a]	4.40[b]	4.07[c]
Identified Regulation	4.12[a]	4.65[b]	4.45[b]
External Regulation	4.76[a]	4.61[a]	4.62[a]
Amotivation	3.19[a]	2.91[b]	2.87[b]

Table 4 presents students' motivation relative to video lectures, laboratory stations, and case studies based on the Situational Motivation Scale (SIMS). Situational intrinsic motivation was greatest for students completing laboratory stations followed by case studies and lectures, respectively. Students perceived greater identified regulation with laboratory stations compared with video lectures and case studies. We observed no differences in external regulation between instructional formats. However, students' amotivation was higher following video lectures compared with laboratory stations and case studies.

Table 3.5. Least squares means for animal sciences introductory course student groups across three experimental periods at weeks 7, 9, and 10 of the 16-week semester (n=501) for percent engaged students based on the Behavioral Engagement Related to Instruction (BERI) protocol. No significant difference (p >0.05) was observed between values with the same superscript.

	Video Lecture	**Lab Station**	**Case Study**
% Engaged	63.12^{a}	81.29^{b}	73.17^{b}

Table 5 shows the mean percent of each student group behaviorally engaged during each learning activity based on the Behavioral Engagement Related to Instruction protocol. Behavioral engagement was significantly higher for groups completing laboratory station activities. No difference was observed between behavioral engagement with video lecture and case study activities.

3.7 Discussion

Our objective was to investigate situational interest, motivation, and engagement in students relative to different instructional formats used in an introductory course. We involved students in video lecture activities representing passive learning, and case study and laboratory station activities with problem-based components. In addition to being problem-based, laboratory stations involved students in hands-on learning. We hypothesized that the quality of students' experience would differ for each activity, resulting in differing manifestations of situational interest, intrinsic motivation, and behavioral engagement (Krapp, 2005).

We found significant differences between activities' effects on situational interest, situational intrinsic motivation, and behavioral engagement. In our study, students involved in problem-based, hands-on laboratory stations experienced the most situational interest, situational intrinsic motivation, and behavioral engagement, followed by students engaged in problem-based case studies and lecture-based treatment groups. Our findings add to a growing body of literature documenting the benefits of problem-based and hands-on activities (Barrows, 1986; Dhanapal & Shan, 2014; McDonald, Reynolds, Bixley, & Spronken-Smith, 2017). Many have shown that students tend to prefer problem-based learning and hands-on activities to lecture-based instruction, finding these approaches more enjoyable, interesting, and motivating (Abrahams, 2009; Hodson, 1990; Middleton, 1995).

In contrast, we found external regulation and identified regulation were similar across treatments. Students reported relatively high levels of each type of extrinsic motivation compared with intrinsic motivation. Extrinsic incentives which may be responsible include the low-point-value grade we offered students for completing assigned activities and value-based incentives (e.g. avoidance of guilt, social image concerns) (Underhill, 2016). Although both intrinsic and extrinsic rewards function within rich networks of motivators determining achievement behavior, the role of extrinsic rewards remains controversial in education (Hidi & Renninger, 2006). While extrinsic motivation can serve important roles in facilitating internalization processes—particularly when individuals have low initial interest in tasks (Hidi & Harackiewicz, 2000; Zimmerman, 1985) — extrinsic rewards can also undermine intrinsic motivation (Hewett & Conway, 2016). More research investigating the complex interactions between types of motivation is needed to understand internalization of regulation for different types of academic activities (Hidi & Harackiewicz, 2000; Rigby et al., 1992).

As research on active learning instruction advances beyond dichotomous consideration of active and passive learning environments, considering specific types of active learning and their defining characteristics is becoming increasingly salient. As Holstermann and colleagues (2010) point out, problem-based and hands-on learning can be implemented through a variety of methods—each with different motivational implications. For example, Barrows (1986) claims that problem-based methods allowing more free inquiry or incorporation of prior knowledge may more effectively support student motivation than more structured methods like the written problem-based case studies employed in our study. Problem-based activities can also vary in the means used to present the problem. Although text-based resources have traditionally figured prominently in problem-based learning, activities including hands-on components appear to be increasing in popularity (Barrows, 2000; Hmelo-Silver, 2004; Linn & Slotta, 2006). Problem-based activities requiring students to consult various resources may support learner motivation and interest by enhancing students' senses of inquiry, excitement, enjoyment, and authenticity (Bergin, 1999; Hmelo-Silver, 2007).

For decades, hands-on learning through laboratories has been foundational to promoting interest and motivation in K-16 science education (Hofstein & Lunetta, 2004). Tying content knowledge to physical experience, Kontra and colleagues argue, activates students' sensorimotor brain systems and enhances perceived meaningfulness (2015). Importantly, factors within learners may affect their reception of these techniques. Zacharia, Loizou, and Papevripidou (2012) propose that hands-on, physical learning experiences may be most influential in early stages of learning when students often must correct prior misconceptions. In contrast, Holstermann (2010) reported no significant differences in interest between learners with and without prior experience related to hands-on learning activities. Haigh (1993) explains that in some cases, activities with both hands-on and problem-based learning components may be overwhelming to students, reducing their perception of competence and subsequent motivation. Our study did not assess students' prior experience or attitudes toward activities, which may be important topics for future research.

Students' instructional preferences may also be influenced by their personal motivational traits and orientations. Kempa and Diaz reported that students categorized as "conscientious" tended to prefer more formal learning environments, whereas other students tended to be more open to learning through problem-based and hands-on activities. Our study did not address the motivational implications of personality differences in students. Factors such as pre-existing individual interest, self-efficacy, and achievement goals may have influenced learners' experience in our study and are an important topic for future research.

In our case study and laboratory station activities, group dynamics may have also affected students' experience Savin-Badin (2000) lists over-dominant group members, an incentive to freeload, and personality clashes as among possible disturbances affecting problem-based activity function (Savin-Badin, 2000). Although our study assumed these differences were homogenous across treatments, it is possible that different instructional formats may alter the magnitude of realized group-related effects. Although group dynamics can have negative effects, they also play an important role in learning activities' effectiveness (Barrows, 1986; Rotgans & Schmidt, 2014;

Webb & Engar, 2016). Alvarez-Bell, Wirtz, and Bian (2017) showed that both involvement in group learning and feelings about group learning predicted engagement in active learning settings.

Activities like the laboratory stations and case studies we tested—which emphasize collaboration and provide students more choice—may also more effectively support learner motivation by promoting autonomy and relatedness. Fulfillment of basic psychological needs for competence, autonomy, and relatedness has been demonstrated to support intrinsic motivation (Ryan & LaGuardia, 2000). According to Krapp (2005), basic psychological needs fulfillment may also contribute to the development of interest. Krapp bases this conclusion on a study by Wild (2000) which used hierarchical linear modeling (HLM) to demonstrate that basic-psychological-needs-related experiences significantly predicted individuals' development of interest-related motivational orientations relative to a vocational education program. From a qualitative perspective, in Lewalter and colleagues' (1998) study of content-specific interest relative to a vocational education program, participants spontaneously mentioned basic psychological needs fulfillment when asked to explain the initiation and maintenance of their interest in the subject.

Finally, our nomothetic approach captured only a peripheral view of student engagement with specific activities during a short timeframe—bracketing out the social, historical, and cultural components reflexively influencing engaged participation (Azevedo, 2012). Although our student sample was diverse in many dimensions, it was a convenience sample of students enrolled in the introductory animal science course. Results may not be generalizable beyond this or similar populations. Future studies integrating insights from both psychology and sociocultural learning theories may provide more insight on the psychological processes and structural features underlying engagement and achievement within specific communities of practice. Similarly, long-term studies from a developmental perspective may capture a fuller view of engagement than our study of situational factors during a single semester (Chen et al., 1999).

3.8 Conclusions

Our research considered students' experience with three educational activities in an introductory course from multiple perspectives—integrating third-party observation of behavioral engagement with self-report measurement of situational interest and motivation. Participants in our study engaged most deeply and experienced the greatest interest and intrinsic motivation with hands-on, problem-based laboratory stations, followed by problem-based case studies and video lecture activities. Our results show that both intrinsic and extrinsic sources contributed to students' motivation to engage with activities, but that problem-based case studies and hands-on, problem-based laboratory stations were associated with greater internalization of motivation. Compared with video lecture, case studies and laboratory stations were rated more enjoyable, novel, challenging, and attention-demanding. The greater overall situational interest experienced during laboratory stations and case studies indicates that educators and instructional designers can leverage these and similar activities to create learning environments that promote interest, intrinsic motivation, and engagement.

3.9 References

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PART II

The following two chapters describe an online program contextualizing STEM within poultry science. In addition to effectively increasing content knowledge, the program was designed to enhance students' interest in STEM and poultry fields. Chapter Four describes program effects on students' knowledge, awareness, and interest in the poultry industry. In contrast, Chapter Five focuses on the program's effects on students' STEM learning and STEM motivation. In addition, Chapter Five provides background on teacher and contextual factors influencing the program's implementation. Instructional design features related to target outcomes are overviewed separately, in each chapter.

CHAPTER 4. POULTRY IN THE CLASSROOM: EFFECTIVENESS OF AN ONLINE POULTRY-SCIENCE-BASED EDUCATION PROGRAM FOR HIGH SCHOOL STEM INSTRUCTION

4.1 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 (NAP, 1998). 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 for STEM concepts: making learning 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, 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 contextualizing STEM learning in poultry science. To enhance student learning and interest in poultry, seven 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 program effects on student knowledge and awareness of the poultry industry 2) explore learning and motivational effects of program instructional design.

4.2 Materials and Methods

4.2.1 Instructional Design

To increase high school students' knowledge, awareness, and interest in poultry science and related careers, seven online integrated learning modules were created to showcase the laying hen industry. Modules were 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. Purposeful contextualization of integrated STEM learning was guided by the instructional design framework recently introduced by Robinson and colleagues (2018). Overarching themes of each module are presented in Table 1.

Table 4.1. 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

Ample evidence supports that positive learning experiences stimulate interest, deepen knowledge and comprehension, and influence goals and motivation (Lent, Brown, & Hackett, 1994; Hidi & Renninger, 2006). 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 the state 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 was accurate, face valid, and content valid. Throughout development, the expert panel assisted with revisions to ensure alignment with program aims.

Program design emphasized learner-centered, student-directed learning for two reasons: (1) because most teachers have relatively little experience or expertise in poultry teaching and (2) because 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-minute 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.

Beyond creating awareness about the poultry, the program was designed to leverage instructional design principles to enhance students' interest in poultry (Keller, 1987; Lent, Brown, and Hackett, 1994). To this end, it utilized innovative instructional technologies to engage students in poultry science learning including interactive figures, video, 360-degree video, and simulation games. Simulation games were included in four of the seven modules. 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. An overview of one module is provided in Table 2.

Table 4.2. Sample module content in online STEM-poultry learning resources for high school students. Module Topic: Laying Hen Anatomy, Physiology, and Biology.

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

Table 4.2 continued

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

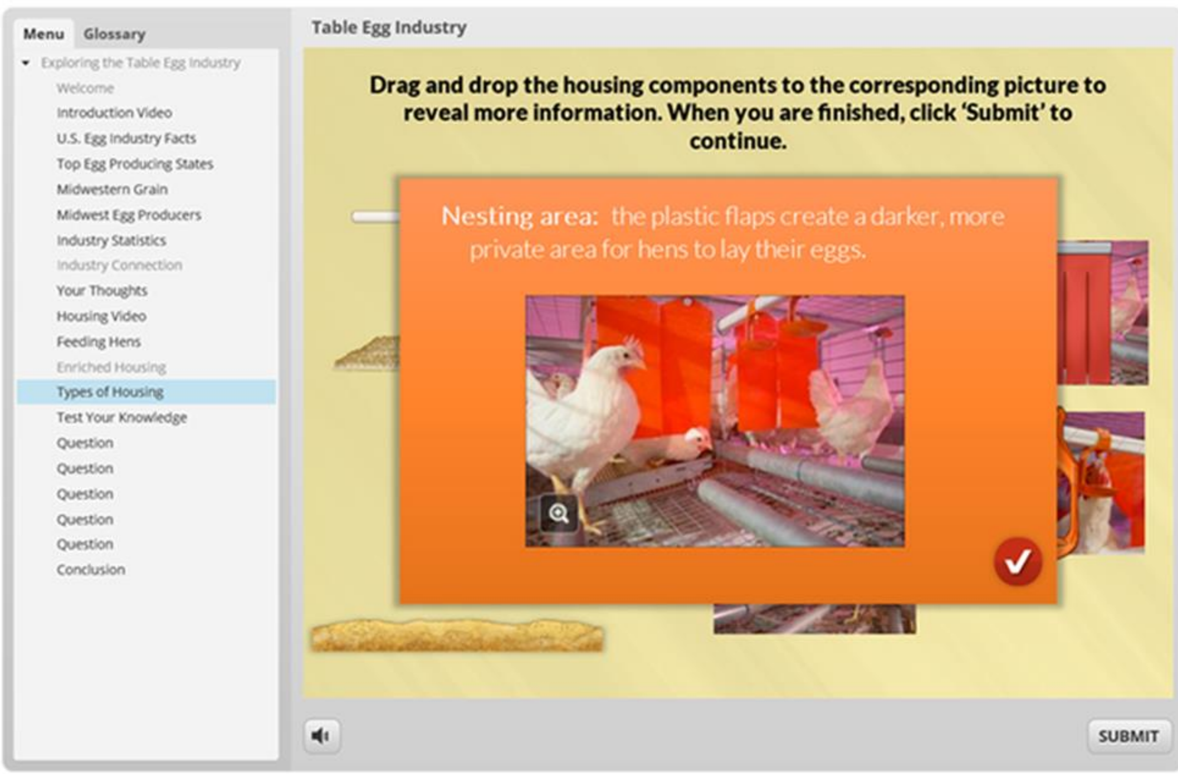

Figure 4.1. Snapshot of the student-view for a module in the online poultry program.

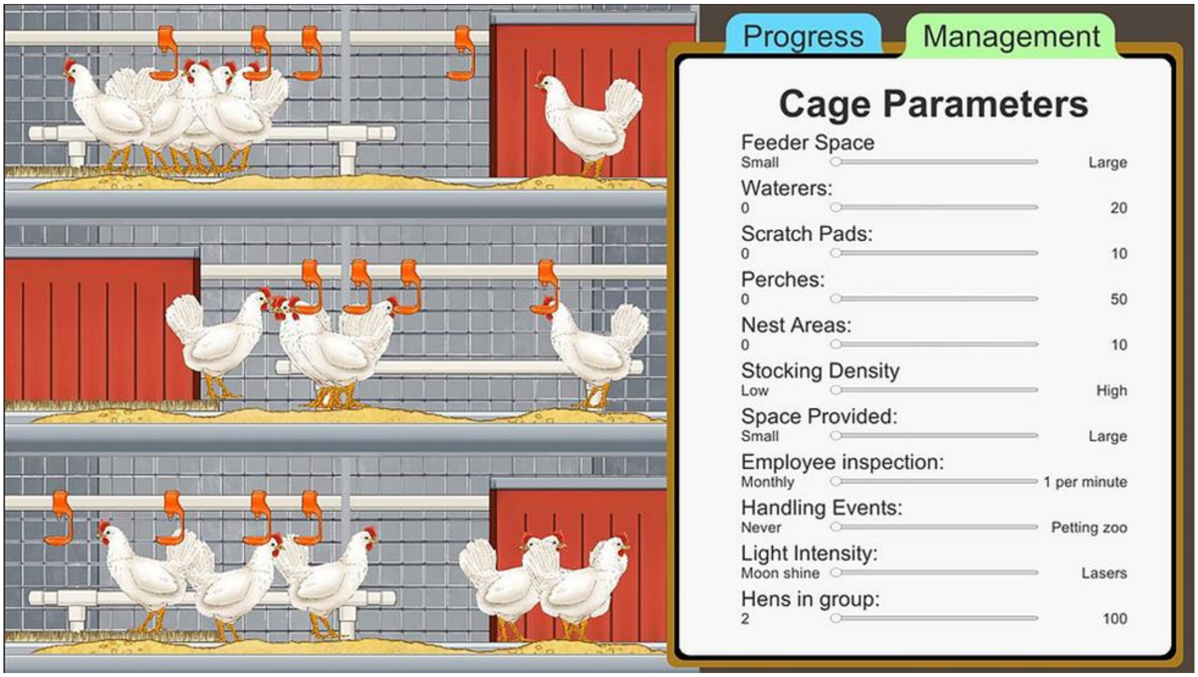

Figure 4.2. Still of the simulation game within the online poultry program.

Performance feedback throughout the program was designed to enhance learning and support students' competence beliefs. Performance feedback delivery can support or undermine interest and motivation by altering learners' competence beliefs (Freiberger, 2012). With novel environments or tasks, positive feedback may be of particular importance in supporting students' competence perceptions and continued interest (Dupret, 2016). 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 increase 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. Research has shown that vicarious experience and social persuasion are important factors in determining career interests and goals (Lent, Brown, and Hackett, 1994).

4.2.2 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. No limits were placed 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 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.

Table 4.3. Demographic information of participants in online STEM-poultry program. N =169.

		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

4.2.3 Study Design

This case study used a mixed-methods, qualitatively-driven approach and employed a sequential explanatory design (Johnson and Turner, 2003; Creswell, 2003; Yin, 2013). Mixed-methods designs take advantage of both methods' complementary strengths and allow for more rich, robust analysis (Green, Caracelli, and Graham, 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, thick case descriptions, researcher reflexivity, collaboration with participants, and peer debriefing (Lincoln and Guba, 1985; Creswell, 1998; Creswell, 2003).

4.2.4 Poultry Knowledge Comprehension Tests

Immediately prior and following the first six 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 modules’ content. The expert panel and two volunteers not involved with the research reviewed the content quizzes to establish face and content validity.

4.2.5 Survey Instrumentation and Administration

The student pre-program questionnaire comprised demographic information and items to measure poultry interest adapted from the Individual Interest Questionnaire (IIQ) developed by Rotgans (2015). 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). Raw Cronbach’s alpha for the IIQ was 0.97, suggesting excellent internal consistency of the instrument in our sample (Tavakol, 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 and the post-questionnaire following the program and within 16 weeks of the program start date.

4.2.6 Teacher Focus Group

All teachers were invited to participate in a focus group held within one week of the program’s completion. During the focus group, a trained facilitator used semi-structured prompts to lead the three 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).

4.2.7 Quantitative Data Analysis

All 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 $p<0.05$.

4.2.8 Qualitative Data Analysis

The study's qualitative phase employed a descriptive approach (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 and Hemphill (2018). Selected representative participant responses are presented for each theme.

4.2.9 Reflexivity Statement

This research was conducted as part of on-going efforts to use evidence-based strategies improve poultry science education in the Midwest and nationally. Several authors have direct ties to the poultry industry. All authors currently reside in the state in which the research was conducted.

4.3 Results

4.3.1 Program Effects on Participants' Knowledge, Awareness, and Interest

Both quantitative and qualitative results indicated increased knowledge and comprehension of the poultry industry following 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 (Durlak, 2009). A paired t-test indicated no difference in students' average IIQ-based interest in poultry before (M = 1.84 ± 0.06) and following (M = 1.87 ± 0.07) the program (p = 0.67, df = 168). Participants' qualitative responses offer further insight on the program's positive effects on knowledge, awareness, and interest.

Table 4.4. Paired t-test comparison of mean student scores on 10-point content quizzes before and after each module of online poultry-STEM program. N = 169.

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

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.

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." Gains in poultry knowledge were accompanied by increased confidence, as student statements illustrate: "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.

Table 4.5. 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.

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.”

Table 4.6. Representative statements from students and teachers for themes related to program effects on knowledge 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.” “It taught me about the welfare and needs of poultry.”
Program Made Participants More Confident in Ability to Succeed in Poultry	
Students	“I now know that if I ever wanted to go into the poultry industry I most likely would be able to because it isn’t very difficult to learn and I’d assume it isn’t hard to actually do either." “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.” “My confidence is much higher at learning and absorbing new information about poultry.”

Table 4.6 continued

Program Increased Participants' Interest in Poultry	
Students	"I have wanted to learn more because I found the poultry modules interesting." "It has changed me by me being more curious in poultry." "I have started to want to learn more about poultry through each module." "I have become more interested in the poultry industry. "It has intrigued me and I have learned a lot more about chickens than I ever thought before."

Table 4.7. Selected quotes from students representing the fourth theme: individual differences moderating program effects on interest.

Program Not Relevant or Enjoyable for Students without Pre-Existing Poultry Interest	
Students	"It taught me some about chickens but I didn't learn anything big and don't expect this to help me at all later in life." "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." "I don't want a poultry related career so this information was pointless to learn about." "My confidence to learn poultry has not changed because I'm not a fan of poultry and so I'm not looking for a career in that field." "It is just hard for me to enjoy because I don't want to get a career in poultry." "They have broadened my understanding but I don't think I would willingly choose to learn poultry science." "I may have learned some new info on the industry, but the topic is just not interesting and I didn't put in that much effort. I don't think I will learn anymore poultry science after this module is over." "Poultry science is extremely boring and such a specific kind of science that it's irrelevant to anyone not involved in the industry. Because of that, I have no desire or confidence to learn poultry science." "I won't ever go into it…but it was fun to learn about."
Teachers	"I believe students need to have a basic animal science knowledge base to appreciate the modules." "My students aren't all rural. Some of my suburban and urban students didn't see much application, even though I tried to explain…it [sic] a huge part of our economy."

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 4.8. Selected statements representing themes related to changes in awareness of the poultry industry and poultry industry careers.

Program Participation Changed Perceptions of Poultry Industry	
Students	"It helped me learn what producers go through and how hard it can be to make sure everything is right at the chicken houses." "It showed what life was like on an actual poultry farm." "It showed us a positive outlook on the poultry industry." "It taught me how companies handle animal welfare." "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." "I have a clearer idea of all the work it takes to keep hens."
Teachers	"It helped students make connections between biology and their lives and the lives of chickens. I was able to use the modules as a positive portrayal of the poultry industry when they've maybe seen more dramatic depictions aimed at making chicken farming appear less tolerable." "It exposed my students to something new to them. It helped my agriculture students understand poultry and poultry production better…" "I think it opened up in some regards a bigger picture across not only poultry, but across the board."
Program Participation Increased Awareness of Poultry Careers	
Students	"I understand how many different job opportunities there are." "I now understand how many job opportunities there are in poultry." "Now I have a grasp of what some businesses look for in workers." "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." "… I don't know if it really was oh, that's what I wanna do, but it opened up their eyes to if I get out and I do work in this industry, this is what I'd be doing and they'd have a little bit more knowledge." "Provided great examples of careers in the poultry industry…exposed students to poultry topics, pictures of processes within the industry and career opportunities."

4.3.2 Program Instructional Design

Based on qualitative data, 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.

Table 4.9. Representative quotes illustrating participants' perceptions of program instructional design.

Varied, Interactive Instructional Design in Program Enhanced Learning and Interest	
Students	"It helped me learn what producers go through and how hard it can be to make sure everything is right at the chicken houses." "It showed what life was like on an actual poultry farm." "It showed us a positive outlook on the poultry industry." "It taught me how companies handle animal welfare." "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." "I have a clearer idea of all the work it takes to keep hens."
Teachers	"It helped students make connections between biology and their lives and the lives of chickens. I was able to use the modules as a positive portrayal of the poultry industry when they've maybe seen more dramatic depictions aimed at making chicken farming appear less tolerable." "It exposed my students to something new to them. It helped my agriculture students understand poultry and poultry production better…" "I think it opened up in some regards a bigger picture across not only poultry, but across the board."
Predominantly Online Platform was Boring, More Hands-on Components Needed	
Students	"I did not learn poultry very much. The modules were boring." "There could be more games throughout the modules."
Teachers	"More interactive things would be better." "Maybe a quick hands-on activity to go with each module." "It also needs a project (hands-on activity) to go with it to reaffirm what they just learned. My kids thought it was boring because they just stared at a screen." "More interactive, more things that interest the students. Like hatching eggs, learning to candle. They need more hands on in order to learn."

4.4 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 assessed in this research appears to have served as an effective poultry learning resource for our sample: increasing most students' poultry knowledge, awareness, and interest.

The significant, moderate to large increases in mean content quiz score for all modules indicate that 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 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 two 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, 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 three 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 (Walkington, 2013; Holstermann et al., 2010). Our study participants themselves hinted at a desire for more hands-on, interactive components and options for students with less prior experience. 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 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' rich descriptions of their experiences show that learner-centered poultry education programs can create positive poultry learning experiences for many people. 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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CHAPTER 5. HIGH SCHOOL STUDENT AND TEACHER PERCEPTIONS OF AN ONLINE LEARNING EXPERIENCE INTEGRATING STEM AND POULTRY SCIENCE

5.1 Introduction

This study examined an online learning experience contextualizing STEM within poultry science and designed to increase Indiana high school students' awareness of the poultry industry. The online learning experience assessed was part of a larger initiative addressing poultry workforce pipeline issues by increasing Indiana high school students' exposure to related educational and career opportunities. The Midwest poultry industry, like other agriculture industries, is facing heightened employment demands and a shortfall of qualified candidates interested in filling career openings (U.S. Poultry & Egg). Table 1 illustrates the dismal interest in poultry careers among graduates of several Midwest institutions.

Table 5.1. Undergraduate program coordinators' estimates of the number of graduates from their institution entering the poultry industry after graduation for several prominent Midwest animal sciences programs.

State	University	# of graduates who fill a job in poultry industry	Annual poultry jobs available for college graduates[1]
Iowa	Iowa State University	5	8,000 – 10,000
Indiana	Purdue University	2	
Ohio	Ohio State University	10	

[1]Annual poultry career availability was estimated based on the 2012 USDA Census of Agriculture Highlights and the U.S. Poultry and Egg Association Poultry Feeds America publication.

The poultry workforce pipeline is acutely deficient in Indiana. Nationally, Indiana ranks first in duck production, third in egg production, and fourth in turkey production (USDA NASS, 2012). Poultry producers and processors directly contribute $4.25 billion to Indiana's economy annually (USDA NASS, 2012). Over 7000 Hoosiers are employed by the poultry industry (USDA, 2012). To keep pace with projected industry growth, the Indiana poultry industry will need many more college graduates interested in and prepared for poultry careers.

The Midwest poultry industry's workforce dilemma illustrates the larger need for career-ready graduates. Although career readiness has long been a goal of secondary education, recent reports of discouraging trends in student proficiency have prompted renewed focus in refining high school curricula that emphasize career-readiness skills (National Assessment Governing Board n.d., World Economic Forum, 2016). To successfully transition to the workforce, students must be able to integrate academic and technical competency with soft-skills, awareness of career opportunities, and knowledge of skills and experiences relevant to career goals (Symonds et al, 2011; National Association of Colleges and Employers, 2014; Achieve, 2016).

Despite the recent attention, promoting career readiness skills has proven difficult (Achieve, 2016). Formal education has not traditionally encompassed employability skills, with content standards instead focusing goals on academic and technical realms (ACT, 2010). Still, U.S. schooling lags behind that of other developed countries; notably inferior at developing students' competencies in science, technology, engineering, and mathematics (STEM) fields (PISA, 2015). Recent work suggests inadequate number and rigor of course offerings and a lack of integration between coursework and out-of-school experiences are contributing factors (Rakich, 2016).

Creating a pathway to STEM career readiness is increasing in importance as the U.S. struggles to remain globally competitive in STEM fields. STEM professionals currently make up almost 20% of the U.S. workforce, and the need for STEM-trained college graduates is predicted to expand in the next decade (PCAST, 2012). Growth of STEM occupations is driven in part by expansion of the U.S.'s agriculture workforce, of which 27% of annual openings for college graduates are in STEM (USDA NIFA). However, the number of college graduates available to fill career openings is expected to fall short of both STEM and agriculture workforce needs (USDA NIFA; NAP, 2014).

In any field, a lack of college graduates interested in careers can stem from both enrollment and degree completion trends (NAP, 2014). Students' secondary education goals, career goals, and persistence in pursuing career tracks are strongly related to their high school experiences (NCES, 2001). As such, recent work has focused on providing high school youth opportunities and exposure within target disciplines to support the pipeline of graduates pursuing related careers (Scherer, 2016). However, experiences vary in their effectiveness at increasing students' interest and motivation towards career paths, and incorrectly applied interventions can reduce interest (Blickenstaff, 2005).

A report from the National Academies Press suggests that integrated STEM contextualized in agriculture education may present opportunities for bolstering career interest and supporting workforce needs in both fields (NAP, 2014). Broadly defined, integrated STEM-agricultural education consists of combining aspects of each discipline to achieve learning outcomes. Contextualizing STEM within agriculture can make concepts more relevant and engaging, increasing student motivation and achievement. However, implementation of integrated STEM-agriculture has been limited by a lack of coordinated effort to provide and update resources for teachers. As nationwide efforts shift K-12 education toward integrated STEM instruction methods, more research is needed to refine this approach (NAP, 2014).

5.2 Theoretical Framework

Nadelson and Seifert (2017) define integrated STEM as "the seamless amalgamation of content and concepts from multiple STEM disciplines." Functionally, integrated STEM requires contextualization. Domain-general contexts allow concepts from multiple STEM disciplines to be considered simultaneously (Nadelson and Seifert, 2017). In many cases, the tasks, concepts, and problems in agriculture are appropriate as contexts for integrated STEM instruction (NAP, 2014). Contextualized STEM learning experiences may improve student motivation, improve knowledge transferability and recall, and assist the development of 21st century skills (Driscoll, 2005; Hmelo-Silver, 2004; Nadelson and Seifert, 2017). However, achieving the benefits of contextualized learning requires purposeful planning of integration between STEM and agriculture (Robinson et al., 2018).

Robinson and colleagues (2018) recently introduced a framework to assist integration of STEM within agriculture instruction. The authors identified five characteristics of integrated STEM education: "(1) Instruction integrates two or more subject areas within a context; (2) Students' work should be practical and/or authentic; (3) Intentionally target critical thinking and problem-solving skill development; (4) Learning is student-centered; (5) Technology is regularly used." To support the development of employability skills, career motivation, and content proficiency, we designed seven online modules using principles of integrated STEM-agriculture education. The following is a summary of each characteristic's incorporation into the program design.

5.2.1 Authentic, Problem-based Learning

The online modules in our program incorporated science, technology, engineering, and mathematics within the context of real-world poultry science and laying hen management challenges. Contexts can enhance the meaningfulness and relevance of concepts for students (Nathan et al., 1992). Compared with traditional instruction, learning in context can improve recall and transferability of knowledge (Driscoll, 2005; Hmelo-Silver, 2004). Integrating STEM within the context of agriculture has been demonstrated to result in more efficient learning and deeper understanding of STEM concepts (Drake and Burns, 2004; Krathwohl, 2002). In our program, STEM learning was incorporated in practical poultry science topics including physiology, welfare, and facility design. Our objective was to create interest by providing students authentic problems requiring scaffolded STEM learning to advance (Cooper et al., 2015). For example, students were asked to play the role of poultry farm manager to calculate a facility's manure production in terms of annual tons, convert it to tons of nutrients, and determine appropriate manure application rates for crop production.

Critical thinking and problem-solving skills were intentionally targeted through problem-based learning. Problem-based learning (PBL) has been documented to increase employability skills such as problem-solving skills, communication skills, critical thinking skills, and adaptability (Albanese & Mitchell, 1993; Hmelo-Silver, 1998; Koray et al., 2008; Kadir et al., 2015). Although a variety of methods can be described as "problem-based," PBL can be loosely defined as allowing students to self-direct their learning by working through scenarios with authentic, ill-structured problems (Savery and Duffy, 1995). Four of the seven online modules included an interactive simulation game which involved students in making management decisions and addressing issues for a poultry facility. Although the simulation game provided background information for each scenario, students were responsible for finding needed information and using it to create their own solution. For example, one module posed learners with poultry health issues related to facility design. Students learned pathology and welfare concepts in order to recommend and defend solutions.

5.2.2 Learner-Centered, Motivating Instruction

Principles of learner-centered instruction served as the basis for module design. With problem-based, self-directed learning, learner motivation is key to success (Harun et al., 2012).

We designed modules using the design framework of the ARCS motivation model to enhance learner motivation (Keller, 1987). The ARCS model has frequently been used in the development and evaluation of online and blended courses (Keller, 2004). It centers on maximizing four components of motivation: attention, relevance, confidence, and satisfaction. The modules for this study employ tactics such as performance feedback, varied delivery, and localization to support the four motivation components of the ARCS model.

To create a sense of inquiry and hold student attention, the modules included intriguing discrepancies throughout multiple self-paced scenarios. For example, in one scenario students responded to a sudden decrease in egg production. Students' sense of relevance was supported by localization of content. All videos within the modules took place at Indiana poultry facilities and featured Hoosiers with careers in the poultry industry. Demonstrating the utility of content proficiency to students' career goals further served to increase the modules' perceived relevance to students (Frymier and Shulman, 1995). Finally, student confidence and satisfaction were supported through enactive mastery experiences with consistent rewards (Bandura, 1985). As students were guided through problems successfully, animated characters announced students' scores and provided encouragement.

In addition to utilizing the ARCS model for instructional design, the modules were designed to build on students' prior knowledge and prompt reflection. At various checkpoints, learners received reflection prompts and wrote several paragraphs summarizing the meaningfulness of the content. Reflecting on contextualized learning can improve self-regulated learning skills such as metacognition (Meyer and Turner, 2002). Three to five suggested prompts were also provided to teachers to facilitate discussion following the modules, although we did not design assessment to confirm their application in classrooms.

5.2.3 Incorporation of Technology

Robinson and colleagues (2018) suggest that technology can be incorporated in integrated STEM teaching in terms of both content and content delivery. Program content highlighted technologies used for facility management including climate control, manure management, egg collection, and egg processing. Technologies served as the basis for many problem-based scenarios.

5.3 Purpose and Objectives

The purpose of this study was to explore and describe the perceptions of high school students and teachers involved in an online integrated STEM learning experience using the context of poultry science. The following objectives guided our research:

1. Describe student motivation during the program in terms of perceived interest, enjoyment, relevance, and autonomy.
2. Compare student performance on content quizzes before and after completing each module.
3. Explore teacher and student perceptions of program effects on students' STEM-learning, 21st century skills, and STEM motivation.

5.4 Method

5.4.1 Population and Participants

Indiana high school teachers of junior- and senior-level agriculture and biology during the fall 2018 semester formed the population for this study. We selected a convenience sample, placing no limits on the number of enrollees. We recruited teachers with word of mouth, social media, and email listservs. A total of 16 schools enrolled in the study, resulting in participation of 499 students in 23 classrooms. Class sizes varied substantially but averaged 21 students (s = 11.14). Data were not collected for students who did not provide assent or parental consent, and those who failed to complete the post-questionnaire. In total, we matched 169 complete responses from students for pre- and post-questionnaires, representing a 34.1% response rate. Demographic information of the 169 respondents is summarized in Table 4.3.

5.4.2 Study Design

This study was quantitatively driven and used an embedded design to incorporate qualitative data within a single group pre-test, post-test design (Plano Clark, 2007). We collected qualitative responses in the post-survey and through a teacher focus group to triangulate with quantitative results and explore for common themes.

Students completed the pre-questionnaire immediately prior to using the modules and the post-questionnaire upon completion of the final module and within 16 weeks of starting the program. We administered the online survey using Qualtrics and required responses for each question (Qualtrics, Provo, UT).

A panel of poultry experts including faculty, Cooperative Extension specialists, and industry representatives contributed to module development. The expert panel evaluated face and content validity of the modules and assisted with making necessary changes to ensure the modules and timeframe provided an appropriate context for developing poultry skills.

5.4.3 Instrumentation

The student pre-questionnaire included basic demographic information. The post-questionnaire comprised items on motivation during the learning experience from Deci and Ryan's Intrinsic Motivation Inventory and open-ended questions on self-efficacy and experience with the modules (Ryan, 1982). Although validity of the IMI was first established in laboratory settings (McAuley et al., 1989), it has since been documented as stable in classroom settings (Leng et al., 2010; Cortright et al., 2013). We selected items from interest/enjoyment, value/usefulness, and perceived choice subscales to construct a scale similar to the "Activity Perceptions Questionnaire" used by Deci and colleagues (1994). Raw Cronbach's coefficient alpha for our sample were 0.94, 0.96, and 0.82 for the interest/enjoyment, value/usefulness, and perceived choice subscales, respectively, indicating strong internal consistency of the measure (Tavakol, 2011). A panel of poultry industry representatives and poultry science faculty reviewed content quizzes to establish their face and content validity.

5.4.4 Teacher Focus Group

Within one week of the end of the program, a focus group was held for teachers involved in the program. A trained facilitator used semi-structured prompts related to program design features to lead discussion among three teachers in attendance. Focus group responses were audio-recorded and transcribed verbatim using an online service (Verbal Ink, Ubiqus).

5.4.5 Quantitative Analysis

All analyses were completed using SAS software (SAS Institute, Inc., Cary, NC). After verifying the normality of data, summary statistics were computed. Next, paired t-tests were completed to assess differences in interest, self-efficacy, and outcome expectations before and after the online learning experience. Then, multivariate analysis of variance was completed to detect fixed effects of gender, community type, high school classification, course type, and teacher. Finally, Pearson correlation coefficients were used to assess relationships between all variables. For all analyses, significance was declared at $p < 0.05$.

5.4.6 Qualitative Analysis

The study's qualitative phase utilized a descriptive approach involving minimal interpretation of data (Sandelowski, 2000). Two of the researchers coded qualitative responses from students and teachers using the procedures for thematic analysis established by Braun and Clarke (2006). Intercoder agreement was achieved through the collaborative coding procedure described by Richards and Hemphill (2018). In brief, descriptive open coding was used to identify themes repeated in the text. Then, selected quotes representing each theme were grouped into emergent categories that related to the study's theoretical framework. Theoretical categories were then further refined based on commonalities (Auerbach and Silverstein, 2003).

5.5 Results

Average student scores on 10-point content quizzes before and after completing each module are presented in Table 4.4. For all modules, average scores were significantly higher in the post-test compared with the pre-test. Cohen's d indicated medium to large effect sizes for the increase in content knowledge following each module (Hill et al., 2008).

Table 5.2 presents students' self-reported intrinsic motivation in the program. We assessed motivation variables using items from Deci and Ryan's Intrinsic Motivation Inventory (IMI). On the interest and enjoyment subscale—considered a direct measure of intrinsic motivation—students exhibited moderate ratings. Students experienced a great deal of autonomy during the program, as high ratings on the perceived choice scale demonstrate. Perceived choice is a contextual factor that predicts intrinsic motivation (Ryan, 1982). Student ratings were low to moderate on the value and usefulness subscale. This subscale has been used in internalization studies (e.g. Deci et al., 1994) to predict the development of intrinsic motivation towards specific tasks.

Table 5.2. Student Intrinsic Motivation in Program.

Subscale	**n**	**M[1]**
Interest and Enjoyment	169	4.28 ± 0.11
Value and Usefulness		3.02 ± 0.12
Choice		5.92 ± 0.11

[1]Average of Likert scale ratings from (1 – “strongly disagree” to 7 – “strongly agree”) on Intrinsic Motivation Inventory (IMI) items in post-survey ± SEM.

Table 5.3 summarizes teacher perceptions of the effectiveness of the program. Teachers appeared to perceive the program as moderately effective as a STEM learning resource—with variation apparent in their post-survey perceptions of the program’s effects on student STEM learning.

Table 5.3. Teacher perceptions of program effectiveness as an integrated STEM learning resource. N = 7.

Item	M[1]	SD
It helped me improve my instruction of STEM concepts and skills.	4.14	1.64
It helped me support development of skills that will make my students successful in college and the workplace.	4.43	0.73
It helped my students learn STEM concepts and skills.	5.14	1.81
It made STEM learning fun for my students.	4.29	1.03
It made my students more aware of careers in STEM.	5.29	1.16

[1]Average of Likert scale ratings from (1 – “strongly disagree” to 7 – “strongly agree”)

After verifying the homogeneity of variance across groups, a series of multivariate ANOVAs were conducted with gender, community type, high school classification, course type, and teacher as independent variables and with content knowledge gains/losses in each module as dependent variables. A significant association was found between teacher and content knowledge gains/losses, $F(66, 776) = 2.07$ ($p < 0.0001$). No significant associations were discovered for other independent variables. Similarly, MANOVAs using the independent variables mentioned above and dependent variables of Intrinsic Motivation Inventory subscales revealed a significant effect of teacher on student motivation $F(33, 428) = 2.26$ ($p < 0.0001$), but no significant associations between other independent and dependent variables.

Selected quotes from program participants represent each theme that emerged in qualitative analysis. Unless indicated with the word "TEACHER," statements are from student participants.

5.5.1 Theme 1: Interest in poultry determines science learning motivation during program

In many cases, participants commented that the program helped them better understand both STEM and agriculture as disciplines. In general, students reported experiencing more motivation towards science after the integrated learning experience helped them connect learning with realistic problems. The following student statements support this idea:

- "They made me want to learn science more in school."
- "It helped me understand the process of ag and how the body works for chickens. This has helped me with understanding more of the science terms and functions of the body."
- "I have become more energized and motivated to learn in my science class."
- "It has made me be able to comprehend more material I learn in class."
- "I now know the different fields of science and am now more convinced that I want to major in science."

Although students reacted positively to the learning experience as a whole, several students commented that they would have preferred learning science independent of the poultry science context. For example:

- "…we are only learning about chickens compared to general sciences where I would feel like I absorbed a lot more useful information."
- "I don't really think that learning about chickens is teaching me very much useful science knowledge."

Teacher focus group participants and survey respondents indicated that more in-depth science, technology, engineering, and mathematics content would have made the program a better use of class time. Although the program aligned with selected high school course standards, teachers mentioned a need for more STEM integrated within the subject.

5.5.2 Theme 2: Program expands views of scope and applications of STEM

- "It shows the things I learn in school can be applied to different industries."
- "The poultry modules affected my learning of science in school by broadening my horizons and outlooks to what specific science courses I may enjoy and take in the future."
- "The poultry modules affect how well I learn science in school because it shows me many different fields of science."
- "It has helped me understand the process of ag and how the body works for chickens. This has helped me with understanding more of the science terms and functions of the body."
- "It affected how well I learn in science by helping me understand the biology of chickens."
- "The poultry modules helps students connect science they learn in school with a real life example of how it is used."
- "The poultry modules helped me learn that there is more to biology than most know."

Teacher

- "It made it a fun way for them to apply."

5.5.3 Theme 2: STEM-Poultry integration affects perceived relevance of content

The program's integration of STEM and poultry science content received contrasting reviews from both students and teachers. While some students and teachers commented that the integration made content more interesting and enjoyable, some students mentioned that poultry science was not relevant to their lives.

Student:

- "They helped me learn better and also helped me understand science better."
- "It made the topics easier to understand and enjoy a little more."
- "They allow students to get engaged and have fun with learning and it helped with better understanding the information."
- "I want to learn about science but not in poultry."

- “They did not affect my school learning because they are so far removed from anything else I am currently doing in my high school classes. On top of that, the topic is just not very interesting so I was not motivated to put a high amount of effort into it.”
- “The modules are not useful to anyone unless they were already interested in poultry.”

5.5.4 Theme 3: Program develops critical thinking, self-regulated learning skills

Students mentioned developing reading, critical thinking, and study skills as a result of program participation. Several student statements alluded to developments in the holistic, systems thinking characteristic of reflective problem-solving (Reynolds, 2011). In addition, students spoke of developing self-regulated learning skills related to studying, reading, and writing (Zimmerman, 1996). Teachers confirmed that the program’s incorporation of collaborative learning was successful, and cited STEM problem-solving as the source of critical-thinking skills.

Student:

- “It helped me not rely on the teacher.”
- “[My confidence] has improved because I know how to look for important details.”
- “It helped me expand my mind in science classes.”
- “They make me a better reader.”
- “It helps me learn how to study.”
- “It takes it step by step and reflection questions help too. So in science classes I take it step by step and also reflect to see if I understand.”
- “It affected how well I learn science in school by teaching me how to pay attention for a long period of time.”
- “It affects the perspective of things I see.”

Teacher:

- “All of the sudden, it was ‘wait a minute, we’ve got to think a little bit more.’”
- “It offered the small group side of it – gave them the opportunity to talk to each other.”
- “I think it definitely helped them with their critical thinking, especially some of the math problems.”
- “…offered the small group side of it – gave them the opportunity to talk to each other.”

5.5.5 Theme 4: Learning during program increases student self-confidence

For students, skill and knowledge acquisition was accompanied by increased self-efficacy. Importantly, students often mentioned confidence gains in a growth-oriented manner—referencing expending effort towards the modules as contributing to positive beliefs in their ability (Hochandel and Finamore, 2015).

Student:

- "I wasn't really confident about the things I learnt before now, but the completion of the modules has given me more confidence in myself."
- "My confidence has increased because I know so much more."
- "It has made me more interested and confident in myself in learning agricultural science."
- "It has made me more confident because I can learn more if I try harder."
- "[The program] made me want to learn science more in school."

In contrast, teachers expressed some uncertainty related to their ability to facilitate program use in the classroom. "There was much more content in the [program] than what I normally teach," one teacher said. The majority of teachers had little to no expertise in or experience with poultry science. Another teacher commented: "I learned a lot during it, too. There were things that I normally don't teach about because I didn't know them."

5.6 Discussion, Conclusions, and Recommendations

Results from our case study of an online education program contextualizing STEM education within poultry science demonstrate that similar integrated STEM learning experiences can facilitate development of STEM skills, 21st century skills, and motivation towards STEM fields. Our study was limited by the educational program's novelty and the small convenience sample. Although we offer results to assist in formulating similar learning experiences and designing future research, findings may not be generalizable beyond participants. However, in describing student motivation towards the program and exploring participants' perceptions of program effectiveness, several considerations emerged which can inform the development of more effective educational programs. Teacher, student, and classroom characteristics moderating the program's effectiveness appear to have played a significant role beyond the program's instructional design.

For the most part, students appeared to find the program itself enjoyable and motivating. Moderate to high ratings on the interest/enjoyment and perceived choice subscales of the intrinsic motivation inventory show that the program provided students the necessary conditions to experience intrinsic motivation with program activities (Ryan, 1982). Lower ratings for the value/usefulness IMI subscale, however, do not offer strong evidence that STEM motivation in the program might continue to develop through internalization processes. Deci and colleagues (1994) suggested that people are unlikely to internalize regulation (i.e. become intrinsically motivated) for activities or domains they do not consider valuable or useful to their lives. Internalization processes are necessary to dissociate motivation from external contingencies, allowing motivation to continue after rewards or consequences are removed (Deci et al., 1991). Based on our IMI results, it appears our instructional design effectively supported situational intrinsic motivation in the program's STEM learning activities. Evidence suggests that repeated or prolonged situational experiences of situational interest may contribute to the formation of longer-term interest and motivation (Hidi and Renninger, 2006). However, long-term interest maintenance requires an internalized value component—a condition that our program did not appear to produce (Linnenbrink-Garcia, 2010).

Student statements supported quantitative results regarding STEM motivation during the program. A theme of STEM self-efficacy development also emerged from data. However, while many students commented finding program topics fun and enjoyable, others mentioned difficulties relating program content to their lives. Perceived relevance is an important component of interest and motivation which has been shown to affect knowledge retention (Malau-Aduli et al., 2013). Preliminary studies have shown large variation in the motivational effects of integrated STEM programs. Although many studies have associated integrated STEM experiences with positive effects on interest and motivation (e.g. High et al., 2010; Monterastelli et al., 2011), Burghardt and colleagues (2010) documented decreased perceived relevance of mathematics in high school students after a STEM infusion curriculum. However, research connecting perceived relevance and interest to specific features of STEM program design is limited (NAP, 2014). In our study, student statements indicated that that program features which enhanced their STEM motivation did so by increasing their self-efficacy or broadening their views of the scope and applications of science. However, many students mentioned that the context did not make the usefulness of STEM more apparent. Best practices for communicating value to students or selecting culturally relevant contexts for STEM instruction are important topics for future research. Much more work needs to be done before intentionally-designed programs can be implemented to effectively increase STEM career interest and persistence.

Although research on contextualized STEM instruction is still preliminary, a growing number of studies have documented benefits of integrated STEM programs on learning and achievement (Ellis and Fouts, 2001; Hurley, 2001). In our study, significant, moderate to large effect sizes regarding increases in content quiz scores before and after each module indicate that our program increased participants' knowledge of STEM content. The proximity of the experience relative to testing and participants' blindness to correct responses enhanced the internal validity of content quiz results. However, testing effects such as habituation may have influenced results, and our single-group study design prevented causal inference from quantitative data (Cronbach, 1982).

Qualitative data offered further evidence that the program increased students' knowledge and understanding of STEM topics. Although we did not quantitatively measure developments in career readiness skills, qualitative data suggest that the program contributed to the development of skills such as critical thinking, self-regulated learning, problem-solving, and collaboration. Participants mentioned that our integrated STEM-learning program broadened students' understanding of both STEM and agricultural disciplines and the applicability of knowledge in each domain to careers and continued study. Although empirical work assessing soft skill development in integrated programs is limited, integrated approaches in theory have great potential for supporting 21st century skill development (Stohlmann et al., 2012). Morrison (2006) showed enhanced problem-solving and logical thinking with integrated STEM education. Our program's application of problem-based learning may also have contributed to 21st century skill development (Qian and Clark, 2016).

Students' overall experience with our program was influenced by teacher, classroom, and school characteristics, as MANOVAs on motivation and content knowledge variables indicate. Diefes-Dux (2014) demonstrated that teachers' conceptualization and classroom interpretation of integrated STEM instruction affected the learning experience they provided. According to Nadelson and colleagues (2012) teachers with more content knowledge and pedagogical content knowledge enhance benefits of integrated STEM instruction for students. Several teachers in our focus group and teacher survey mentioned feeling uncomfortable with the program content. To our knowledge, our program is the first to contextualize integrated STEM instruction within poultry science. As a result, teachers had no experience with the program itself or similar experiences. More generally, our teacher participants had little experience with poultry science, poultry science teaching, and online learning. As a consequence, the implementation of our program was likely affected by teachers' low knowledge and low self-efficacy towards program content and teaching methods.

Historically, teachers' preparedness for STEM instruction has been a topic of contention. Many teachers lack authentic experience in STEM fields, and consequently feel underprepared to teach (Nadelson et al., 2012). Successful integrated STEM instruction, according to Pang and Good (2000), depends largely on teachers' proficiency with subject matter. The inquiry-based approaches commonly used in integrated STEM instruction may present further difficulty for teachers. Constructivist pedagogies such as inquiry-based learning require a great deal more involvement and knowledge from teachers (Eijwale, 2013). When implemented alongside novel integrated STEM methodologies, teachers may be overwhelmed by the requirements to successfully enact inquiry-based learning in the classroom (Nadelson et al., 2012).

Accordingly, Eijwale (2013) suggests that successful integrated STEM implementation begins with robust teacher preparation. Teachers gain proficiency and self-efficacy as they become experienced with content and methods (Robinson and Edwards, 2012). In our study, we provided teachers a facilitator's guide but did not offer in-person training for using the program. Although previews of module content were made available to teachers several months before the start of the semester, teachers did not have access to the final version of the program until implementing it in their classes. Providing teachers in our program more advance preparation for the program may have facilitated more effective classroom implementation and promoted teacher efficacy.

According to Stohlmann and colleagues (2010), teachers need not only proper preparation, but also support throughout integrated STEM teaching programs. In their study, teachers held regular discussions to share ideas about teaching the lessons, which they reported helped them feel much more comfortable teaching. In our program, we provided no structured opportunities for dialogue between teachers until after the program's conclusion. Future programs providing teachers more opportunities for collaboration may improve the program experience for both students and teachers.

Finally, both teachers and students expressed a desire for more hands-on activities and discussion prompts within programming. Our program was online-based and suggested prompts for short 5-10 minute discussions following completion of the online activities. There is evidence that providing students more opportunities to discuss content, contemporary issues, and career possibilities may enhance their motivation to continue in STEM (Woolnough, 1994). Activities with hands-on components have also been shown to improve students' attitudes towards STEM fields (Myers and Fouts, 1992). Evidence suggests that hands-on approaches may aid comprehension by offsetting the additional cognitive load incurred in the complex, multidisciplinary problem-solving that characterizes integrated STEM learning (Kontra et al., 2015). Future integrated STEM programs may consider supporting teachers in implementing hands-on activities in the classroom by providing lesson plans and materials (Stohlmann et al., 2012).

5.7 Conclusion and Recommendations

Integrated STEM-agriculture programs similar to our poultry science-based online learning program have potential to be effective and motivating STEM learning resources. However, more research is needed to prepare teachers to assume the expanded role of integrated STEM instruction and support them throughout the process, particularly when contextualized in unfamiliar subjects. Further work is also needed to understand how to select and personalize contexts to maximize the relevance of integrated STEM content for students. Future studies considering both the student and teacher experiences associated with integrated STEM learning programs can advance efforts to improve STEM learning and literacy outcomes in K-12 education to meet workforce development needs.

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CHAPTER 6. CONCLUSIONS

Part I examined interest and motivation in an introductory animal science course. Like many other introductory STEM courses, this course had traditionally been taught through lecture-based methods to accommodate the large number of students enrolled. In the fall 2017 semester, the course underwent substantial changes including the addition of a suite of learner-centered activities.

Chapter Two describes relationships between these activities and students' interest in studying animal sciences. Overall, students rated themselves highly interested in animal sciences both at the beginning and end of the semester, though animal science students had higher interest than those from other majors. Students' level of interest in animal sciences was positively correlated with their ratings of the impact of each of the course's learning activities on their interest. Results from Chapter Two indicate that collaborative, problem-based activities may support the development of student interest throughout the semester—promoting learning and engagement.

Chapter Three describes an experiment implemented the year following the course update. In the fall 2018 semester, two of the active learning strategies added to the course (laboratory stations and case studies) were tested alongside lecture to determine the effects of each instructional method on students' situational motivation and interest. Using self-report measures, we determined that laboratory stations and case studies significantly increased students' levels of situational interest and internalized motivation relative to lecture-based instruction. No differences in externally-regulated motivation were observed between groups. However, students reported higher levels of amotivation for lecture activities. Importantly, situational interest and situational intrinsic motivation were highly correlated in our population, lending support to theorized similarities between the constructs. Conclusions from Chapter Three add to a growing body of literature documenting the emotional and motivational benefits of problem-based, hands-on instruction in introductory college courses.

Part II described an online program contextualizing STEM learning within poultry science to address workforce needs and support STEM and agricultural literacy. The program was designed to improve high school students' content knowledge, 21st century skills, and interest in STEM and poultry. In addition, the program was intended to serve as a resource for teachers to facilitate instruction of content outside of typical offerings. Part II presented both qualitative and quantitative data illustrating student and teacher perceptions of the program.

Chapter Four described the program's effectiveness as a poultry education resource. In general, the program appeared to have increased students' knowledge, awareness, and interest in poultry. Significant, moderate to large increases in mean content quiz scores following completing each of the modules indicated that participants in the program had more poultry knowledge after the program than before. Qualitative data indicated that the program improved many students' attitudes toward the poultry industry and interest in poultry careers. However, mean interest in poultry was initially low and remained similar after the program. Low perceived relevance of poultry may have limited the development of interest.

Chapter Five summarized STEM-learning and 21st century skills development related to the program. Although student statements indicated developments in STEM motivation and self-efficacy, students' overall experience with the program was greatly influenced by teacher, classroom, and school characteristics. We concluded that teacher preparation and support provided in the program may have been inadequate to support teachers' confidence in implementing the program. In the focus group, several teachers mentioned feeling uncomfortable with the program content. Most teachers had little to no experience with poultry, poultry teaching, online learning, or integrated STEM instruction. As a result, low teacher self-efficacy may have affected the program's implementation and reception by students. Future programs may consider offering more support to teachers before and during the experience. Chapter Five also highlighted a need to add more hands-on activities and discussion prompts in the integrated learning program.

Overall, these studies add to a growing body of literature supporting the effectiveness of learner-centered pedagogies. The multi-faceted approaches implemented in these studies improved the knowledge, motivation, and interest of many students—serving as effective resources for teachers to use toward these ends. Still, more research is needed to develop models for effective implementation of integrated and interest-driven learning. These approaches are complex, and novel to many teachers and students. Although they present great potential, little research has clarified best practices for their implementation. Similarly, research on interest-driven learning is only beginning to progress from general to discipline-specific, though a great deal of literature suggests important differences between disciplines.

Animal science is a loosely-structured, applied discipline grounded in practice—a broad and deep patchwork of empirical, personal, ethical, and aesthetic knowledge with few general principles to assist learners in navigating it. Animal science expertise is undergirded by situated, tacit forms of knowledge that resist definition and categorization. Although scholarship is just beginning to define the discipline's theoretical grounding, purposes, and practices, it presents many opportunities for educators. Animal science is vivid, diverse, and connected to values, making it an ideal context for interest-driven learning. This, combined with the current dearth of discipline-specific pedagogical knowledge, makes animal sciences a ripe terrain for research and development on learner-centered, integrated approaches.

Although structural inertia holds back shifts toward more adaptive educational paradigms, research on teaching and learning has repeatedly shown more holistic, learner-centered approaches are the way forward. Traditional, didactic pedagogies are insufficient--preparing learners for an imaginary world of absolutes. Expertise in any discrete framework of thought is hopelessly inadequate to inform action in the ever-changing modern world. In reality, truth is plural and contingent. Integrated, learner centered education can prepare students to lead lives of dignity, purpose, and informed action in a changing world. As an applied discipline, animal science is situated to enact this broader view of scholarship. Rather than shoehorning learners into prescribed ways of thinking, learner-centered animal science education can empower students with ways of being that build capacity for meta-awareness and continuous inquiry into possibilities and limitations. Future research on animal sciences teaching and learning can advance understanding of more holistic frameworks for education. Models for integrative, responsive pedagogy have the potential to transform the discipline—creating resilient, lifelong learners with courage to embrace complexity and uncertainty, drive to advance knowledge, and purpose to contribute to the greater good.

APPENDIX A. SURVEYS

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.

Poultry Modules Perceptions Questionnaire (adapted from Deci et al., 1994)

- I believe that doing this activity could be of some value for me.
- I believe I had some choice about doing this activity.
- While I was doing this activity, I was thinking about how much I enjoyed it.
- I believe that doing this activity is useful for improved concentration.
- This activity was fun to do.
- I think this activity is important for my improvement.
- I enjoyed doing this activity very much.
- I really did not have much choice about doing this activity.
- I did this activity because I wanted to.
- I think this is an important activity.
- I thought this was a very boring activity.
- It is possible that this activity could improve my study habits.
- I felt like I had no choice but to do this activity.
- I am willing to do this activity again because I think it is somewhat useful.
- I would describe this activity as very enjoyable.
- I felt like I had to do this activity.
- I believe doing this activity could be somewhat beneficial for me.
- I did this activity because I had to.
- I believe doing this activity could help me do better in school.
- While doing this activity I felt like I had a choice.
- I would describe this activity as very fun.
- I felt like it was not my own choice to do this activity.
- I would be willing to do this activity again because it has some value for me.

PUBLICATIONS

Erickson, M.G., Karcher, E.L., Guberman, D. (Submitted). Undergraduates' experiences of transculturation toward engaged pedagogy through a partnership program in animal sciences. Teaching and Learning Inquiry.

Erickson, M.G., Marks, D., Karcher, E.L., (Submitted). Characterizing student engagement with hands-on, problem-based, and lecture activities in an introductory college course. Teaching and Learning Inquiry.

Erickson, M.G., Knobloch, N.A., Karcher, D.M., Erasmus, M., Karcher, E.L. (Submitted). High school student and teacher perceptions of an online learning experience integrating STEM and poultry science. Journal of Agricultural Education.

Erickson, M.G., Knobloch, N.A., Karcher, D.M., Erasmus, M., Karcher, E.L. (Submitted). Poultry in the classroom: effectiveness of an online education program designed to increase high school students' interest in poultry science. Poultry Science.

Erickson, M.G., Karcher, E.L., Guberman, D. (In press). Interest and active learning techniques in an introductory animal sciences course. North American College Teachers of Agriculture Journal.

Malacco, V.M., Laguna, J.G., Erickson, M.G., Smith, E., Donkin, S.S. (Submitted) Short communication: in search of an optimal dose for glucose tolerance tests in lactating dairy cattle. Journal of Dairy Science.

Worden, L., Erickson, M., Gramer, S., Tap, C., Ylioja, C., Trottier, N., Karcher, E. (2018). Short communication: Decreasing the dietary ratio of n-6 to n-3 fatty acids increases the n-3 concentration of peripheral blood mononuclear cells in weaned Holstein heifer calves. Journal of Dairy Science, 101(2), 1227-1233. doi:10.3168/jds.2017-12696