URBAN HIGH SCHOOL STUDENTS' MOTIVATION IN FOOD SYSTEMS STEM PROJECTS

by

Sarah L. J. Thies

A Thesis

Submitted to the Faculty of Purdue University

In Partial Fulfillment of the Requirements for the degree of

Master of Science

Department of Agricultural Sciences Education and Communication

West Lafayette, Indiana

August 2023

THE PURDUE UNIVERSITY GRADUATE SCHOOL
STATEMENT OF COMMITTEE APPROVAL

Dr. Neil Knobloch, Chair
Department of Agricultural Sciences Education and Communication

Dr. Hui Hui Wang
Department of Agricultural Sciences Education and Communication

Dr. Nathan Mentzer
Department of Technology, Leadership & Innovation

Approved by:
Dr. Rama B. Radhakrishna

To the woman who warned me how much reading graduate school would entail, the woman who showed her family what it means to have faith and trust the Lord, the woman who raised and loved my mom, the wonderful woman who showed me what unconditional love is, this is for you Grandma Hodgskiss.

ACKNOWLEDGMENTS

To Dr. Neil Knobloch, thank you for your patience and support during my master's degree journey. Thank you for your guidance throughout the process. I'm grateful for all the professional development opportunities you encouraged me to participate in. I appreciate your ability to challenge me to think about bigger picture and the application of my masters experience.

To my committee members Dr. Hui-Hui Wang and Dr. Nathan Mentzer, thank you for your guidance throughout this journey. Thank you for your valuable feedback and your encouragement. It was a pleasure to work with you both.

To my undergraduate professors, Dr. Dustin Perry, Nicole Wanago, and Dr. Carl Igo, thank you for building my foundation in education. Thank you for fueling my passion and your support as I began the new chapter of my life of graduate school.

To my friends and family back home, and all over the country now, thank you for your words of encouragement, your emotional support, your listening ears, your prayers, and lastly, thank you for believing in me!

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Food system STEM projects have the capacity to motivate high school students in urban schools. This study explored food as a context to engage students because everyone interacts with food on a daily basis and has had cultural experiences related to food. An integrated STEM approach in combination with a systems thinking approach challenged students to make transdisciplinary connections, view problems from different perspectives, analyze complex relationships, and develop 21st century and career skills (Hilimire et al., 2014; Nanayakkara et al., 2017). The purpose of this study was to describe and explain the relevance students perceive in Ag+STEM content by measuring high school students' self-efficacy, intrinsic value, attainment value, cost value, and utility value after participating in a food system STEM project. The study was informed by Eccles and Wigfield's (2020) Situated Expectancy Value Theory. The convenience sample of this study was comprised of high school students from metropolitan area schools. High school students completed a food system STEM project with a food system context. Quantitative data was collected using the developed Food System Motivation questionnaire. Data were collected through a retrospective pre-test and a post-test. Descriptive statistics were used to analyze the data including means and standard deviations. Relationships were explored by calculating correlations.

There were four conclusions from this study. First, high school students were somewhat interested, felt it was important to do well, and agreed there were costs regarding participation in the food system STEM project. Second, high school students reported higher personal and local utility value motivation after completing the food system STEM project. Third, high school students were somewhat self-efficacious in completing the project tasks and completing the project tasks informed by their cultural identity and experiences. Fourth, intrinsic value and attainment value motivation (independent variables) were related to personal and local utility value motivation and project and cultural self-efficacy motivation (dependent variables). Implications for practice and recommendations for future research were discussed.

CHAPTER 1. INTRODUCTION

High school students completing food system STEM projects using project-based learning in a community context are more likely to be motivated if they see relevance by making personal connections to what they are learning (Eccles & Wigfield, 2020). Classrooms contain high school students that are bored and disengaged because they do not see the relevance of what they are expected to learn and the content does not align with their identity (Berns & Erikson, 2001; Frymier & Shulman, 1995; Lund Dean & Jolly, 2012). Designment may appear as students refusing to contribute to conversations, failing to complete assignments, acting out, and physically not engaging for example (Lund Dean & Jolly, 2012). Instruction is not contextualized and is taught with limited opportunities for real-world application, content is isolated within the domain and taught to the standardized tests. For example, agricultural food production concepts are often taught separately than STEM food production concepts (Stofer & Rios, 2018). Students may not engage because they feel distanced from the application to their lives (Lund Dean & Jolly, 2012). Pedagogical approaches are often teacher-centered teaching approaches that create an environment of passive learning rather than active learning and do not motivate students (Michel et al., 2009; Green, 2015). Classroom engagement is connected to student achievement; high student engagement often leads to higher academic achievement (Schnitzler et al., 2020; Fredricks et al., 2019). There are "negative relationships between academic boredom and multiple learning factors, such as self-efficacy for self-regulated learning, effort, and course grade" (Tze et al., 2015, p. 123). Students need to meet educational standards that prepare with the knowledge and skills needed to pursue post-secondary education or go directly into the workforce (Hilton, 2015; Fredricks et al., 2019). Low engagement in the classroom will not help prepare high school students for college and careers.

Multiple factors contribute to student motivation such as their personal interests, expectations for success, beliefs related to identity, the trade-offs and costs of an activity, previous experiences, and the context (Eccles & Wigfield, 2020). Students need to find enjoyment or significance in the content or context of learning. Food is a social practice that everyone interacts with on a daily basis within their cultural values and practices (Barton et al., 2005). Everyone has had previous experiences with food that have influenced the construction of schema and provided a foundation for the assimilation of new information and learning (Barton et al., 2005; Webb, 1980). That foundation for learning influences students' perceptions of their learning ability and their engagement in the classroom (Schnitzler et al., 2020). Food as a context can engage students, however, food is a broad topic with many complex ideas and relationships with other disciplines. For example, agricultural education courses often focus on food production and technologies, and family and consumer sciences courses often focus on food science, safety, and preparation (The National Council for Agricultural Education, 2015; National Association of State Administrators of Family and Consumer Sciences, 2008). When information is delivered in isolation, it is more challenging for students to transfer their knowledge and skills because connections to existing schema are not clear or are limited based on the context of the information (Hattie & Donoghue, 2016). Applying a systems thinking approach helps students understand the relationships between disciplines and makes student learning experiences meaningful instead of superficial (Barton et al., 2005). Previous experiences that students can connect with and see the relevance of what they are learning can contribute to student motivation (Eccles & Wigfield, 2020). If all students have previous experiences with food, completing an authentic food system STEM project could potentially allow students to see the relevance of the content and serve as a source of motivation.

Pedagogical approaches that are learner-centered compared to teacher-centered give learners some control of their learning (Weimer, 2003). Learner-centered teaching approaches include project-based learning, inquiry-based learning, problem-based learning, and others (Knobloch, 2021a; 2021b; 2021c). Project-based learning (PjBL) is done with authentic real-world problems, but real-world problems are often complex and require a system thinking approach (Nagarajan & Overton, 2019). A systems thinking approach requires learners to take a holistic look at the interdisciplinary connections (Nagarajan & Overton, 2019). Interdisciplinary learning covers many disciplines so if a student is not confident in one discipline, they may be confident in their abilities in another. When disciplines are taught together, student self-efficacy may increase (Jia et al., 2021). The authentic learning environment that the food system STEM project within the local community context creates can help students see the real-world interdisciplinary connections and interactions with professionals contribute to the real-world context (Herrington et al., 2014; Willems & Gonzalez-DeHass, 2012). Interacting with professionals also helps students explore perspectives other than their own (Willems & Gonzalez-DeHass, 2012). The nature of integrated science, technology, engineering, and mathematics (iSTEM) and the opportunities for different levels of integration can support the application of a systems thinking approach (Wang

& Knobloch, 2023). The skills, often 21st century skills, students develop during a system thinking approach are transferable to other contexts outside the classroom such as the workforce (Charoenmuang, 2020). The connections that students make outside the classroom can make content relevant and contribute to student motivation.

Utilizing a learner-centered approach motivates students and leads to higher engagement. “A typical classroom is interrupted 2000 times each year, resulting in a loss between 10 and 20 days of instruction” (Kraft and Monti Nussbaum, 2021 as cited in Reschly & Christenson, 2022, p. 5). Therefore, utilizing approaches or learning experiences that actively engage students in quality instruction is key to make the most of instructional days (Reschly & Christenson, 2022). Project-based learning can be a tool to motivate students to engage in learning, but understanding what aspects of the project motivate them and how they are generating relevance can help educators implement the projects and content. A classroom full of disengaged students can be discouraging to educators, leading to burnout and leaving the profession (Reschly & Christenson, 2022; Fredricks et al., 2019).

Teachers that are burnt out may resort to “teaching to the test” (Posner, 2004, p. 749; Solley, 2007). One problem with teaching to the test is the skills needed to complete the test questions and pass the test may not align with the skills needed to solve real-world problems (Posner, 2004). Rote memorization is often utilized to prepare students for standardized tests and the knowledge and skills are only presented within a discipline-specific exam (Solley, 2007). Students need to know how to seek out information they do not have, but need to solve problems (Posner, 2004). In Desimone’s (2013) study, educators reported teaching to the test can limit the learning experiences of students. Standardized test questions are often closed-ended questions that do not fully require students to reflect on the problem and their knowledge, explain their reasoning, and apply problem-solving skills (Posner, 2004; Solley, 2007). The time limit standardized tests place on students to correctly answer the questions may not allow students to analyze the problem in depth and consider interdisciplinary and real-world connections (Posner, 2004). Standardized testing has turned into an extrinsic motivator with the consequence of diminishing intrinsic motivation of students (Solley, 2007).

1.1 Statement of Research Problem

High school students are not highly motivated to learn in classrooms because the context of the content is not relevant to them or their identity (Legault et al., 2006; Ford & Roby, 2013; Schussler, 2009; Lund Dean & Jolly, 2012). Contextualized learning can help students make real-world connections to the various areas of their lives and make content relevant (Berns & Erikson, 2001; Frymier & Shulman, 1995). The unique identities and diverse previous experiences of students can make it challenging to create opportunities for all students to make relevant connections (Forghani-Arani et al., 2019). High school students are not motivated to learn in classrooms because of the pedagogical approaches applied (Green, 2015; DeVito, 2016). Different pedagogical approaches provide varying levels of social and autonomy support. DeVito (2016) shares that student-centered pedagogy engages students because it gives students opportunities to align their learning to their interests and goals. DeVito also states that teacher centered-learning on the contrary is not as effective as student-centered learning at engaging students at high levels of interest.

1.2 Significance of the Study

This study is significant for three reasons: (1) this study describes how high school students are motivated to engage in the student-centered food system STEM project; (2) the study describes skills developed with an integrated STEM systems thinking approach; (3) the study describes the relationships of student interest and identity to student motivation.

First, this study will contribute to the understanding of student motivation by describing how students find a food system STEM project content relevant. Relevance is unique to each individual and is influenced by their personal experiences, identity and the educational content (Alexander, 2018). Relevance can be established within any domain and for any learner. Relevance is fluid and can be explained by the teacher or discovered by the students. Discovered relevance can motivate students to engage in academic work and be more successful (Alexander, 2018). Currently, teachers are applying teacher-centered teaching approaches that do not allow students to personalize their learning (Emery et al., 2021; Friedel & Anderson, 2017). Applying teacher-centered teaching approaches could be due to their personal beliefs or self-efficacy (Emery et al., 2021). Teachers have a large influence on student engagement in the classroom. (Fredricks et al., 2019). Beyond the teacher and the learning approach, there are other factors that influence student engagement including other students, student demographics, and the academic content (Corso et al., 2013; Fredricks et al., 2019). In contrast, student-centered learning approaches give students control and autonomy of their learning, allowing them to personalize their learning (Bernard et al., 2019). Project-based learning (PjBL) is a student-centered teaching approach that gives students control of their learning (Kokotsaki et al., 2016). PjBL approaches can help students find personal relevance in the content and become interested (Juuti et al., 2021). Personalized learning through PjBL aligns with the strategic priorities of the Indiana Department of Education (*Learner-centered, future-focused education – Indiana,* 2021).

Secondly, the study describes skills developed with an integrated STEM systems thinking approach. The K-12 students in the United States does not perform to the same academic standards as other countries (President's Council of Advisors on Science and Technology, 2010). Therefore, it is the Indiana STEM Advisory Council's vision that "All Indiana students in grades K-12 will graduate with critical thinking skills and be prepared for an innovation-driven economy by accessing quality, world class STEM education every day in the classroom by 2025" (Indiana Department of Education STEM Council, 2018, p. i). A strong foundation in the STEM domains can have a positive effect on the STEM enrollment and retention at the post-secondary level (Stehle & Peters-Burton, 2019); the development of those skills and a foundation of content knowledge should begin in secondary schools and even elementary schools (National Science and Technology Council, 2018). A firm foundation of content knowledge prepares students to take a system thinking approach (York et al., 2019). York et al. (2019) identified a system thinking approach as a tool to motivate students to develop the skills needed to solve real-world problems. Systems thinking is a valuable tool to solve small- and large-scale problems (Nagarajan & Overton, 2019). However, students don't gravitate towards a system thinking approach and instead tend to compartmentalize learning (York et al., 2019). Because system thinking doesn't come naturally, the skills often need to be explicitly taught and students need opportunities to apply the skills (York et al., 2019). Systems thinking and 21st century skills are moving into classrooms to prepare students for careers and develop job candidates that employers are seeking for the workforce (Stehle & Peters-Burton, 2019). The workforce values systems thinking, and the skills associated with it support a collaborative environment and encourage innovation. As such, 21st century skills are developed in real-world contexts that deepen student understanding in meaningful ways and can motivate students (Stehle & Peters-Burton, 2019). The President's Council of Advisors on Science and Technology (2010) identified that STEM experiences can be a tool to motivate and engage diverse student audiences, but there is a need for expanding STEM teaching approaches. An understanding of the skills developed from iSTEM systems thinking projects can inform educators and curriculum developers about effective skill development approaches for diverse student audiences.

The last point addresses the benefits of a systems thinking approach within a real-world agricultural food context. Food system literacy should be developed early in life, and a systems thinking approach within an agricultural food context will help produce educated consumers and develop society's food system and food literacy (Pope et al., 2021). Every learner interacts with and depends on agriculture everyday (The National Council for Agricultural Education, 2015; Pope et al., 2021). A systems thinking approach will challenge students to think about food production holistically and solve problems within the supply chain such as food waste lost to the supply chain (Bora & Katz, 2019; Charoenmuang, 2020). The disconnect creates challenges to solving global issues (Bora & Katz, 2019). "Food literacy is so important to understanding not only our food, but our culture" (Snyder, 2009, p. 283). The connections to food that every learner has, creates more opportunities for students to find relevance in the content and contribute to their motivation to learn.

1.3 Purpose of the Study

The purpose of this study was to describe and explain the relevance students perceived in solving a food system STEM project regarding high school students' self-efficacy, intrinsic value, attainment value, cost value, and utility value upon completion of a food system STEM project.

1.4 Research Questions

1. What were students' intrinsic value, attainment value, and cost value of the food system STEM project upon completion?
2. What were students' utility value motivation (personal & local context) and self-efficacy motivation (cultural & project) before and upon completion of the food system STEM project?

3. What were the relationships among the following variables?
    a. Intrinsic Value
    b. Attainment Value
    c. Cost Value
    d. Personal Utility Value
    e. Local Context Utility Value
    f. Cultural Self-efficacy
    g. Project Self-efficacy

1.5 Limitations

The following were limitations within this study:

1. The positivist paradigm presents limitations with depth of data analysis. Positivists separate themselves from participant interactions, therefore limiting the data analysis to what is collected by the questionnaire instead of for example, focus group interviews (Park et al., 2020).

2. Students could have had previous experiences with a project-based learning approach resulting in bias, positively or negatively, within their responses.

3. The characteristics of the schools' scheduling and organization could affect the results. There will likely be variance within the organization of the different classrooms. There will likely be variance within the organization of the school's schedule, structure, and length of the course. The time the students spent completing the food systems STEM project varied within the classes.

4. During the process of completing the questionnaire, students may have self-generated more relevancy. Completion of the retrospective pre-project items could have influenced the post-project items because of sensitization (Stratton, 2019).

5. The community support or interaction within the project-based learning may influence the relevance generated by students.

6. The study findings are limited by the non-experimental descriptive and correlational design of this study. No causal claims can be made due to the descriptive nature of the study (Devlin, 2021).

7. The population validity of the study was restricted to the convenience sample population (Devlin, 2021). The results were restricted to the Midwest students who have completed the project under facilitators who have completed the specific professional development.

8. There were limitations to how true the measurements were based on the individual perceptions of the scale. The use of the quantitative scale limited the depth of the data collected and analyzed (Nolen, 2020 as cited in Eccles & Wigfield, 2020).

9. Students were participating in the project as part of their class experience, but participation in the study was voluntary.

1.6 Assumptions

1. A positivist paradigm informed the researcher and the assumption that reality can be quantified and explained through observations was made (Little, 2019; Park et al., 2020).

2. A positivist paradigm assumes the researcher has the ability to objectively control the variables (Park et al., 2020).

3. Applying deductive reasoning, data that is collected can be applied to analyze variables and to support and build on present theories (Little, 2019; Park et al., 2020).

4. The researcher was objective when collecting data and separated themselves from the sample participants by using an online questionnaire administered by high school teachers (Park et al., 2020).

5. Social sciences can apply the same methods and can have the same structure as the natural and life sciences (Little, 2019).

6. The teachers were guided by Indiana state learning standards.

7. Teachers have met the implementation requirements for the Incubation Design Challenge, which was approximately 8 hours of professional development.

8. Students reached the engagement requirements for the Incubation Design Challenge as defined by the project rubric in Appendix B.

9. Students answered the questionnaire truthfully and honestly

10. based on their food system STEM project experience.

1.7 Definitions

Food Literacy: "Food Literacy is a multi-faceted concept that comprises three integrated components: Food, nutrition and health; Agriculture, environment and ecology; Social development and equity" (Bellotti, 2010, p. 23 as cited in Cleland & Baird, 2013, p. 10).

Food System STEM Incubation Design Challenge: Project that, with the guidance of trained teachers, holistically challenges students to identify a problem; make local community, career, and user connections; apply Ag+STEM content in the iSTEM approach and with an agro-ecosystyem lens to make systems connections; collect data and identify variables; design a feasible, viable, desirable, and innovative solution; present their projects to scientists and professionals (Wang et al., 2021).

Integrated STEM Education: "Intentionally and purposively blending multiple disciplines (i.e., academic and vocational) to help students meaningfully learn and apply academic content through real-world problems framed in designed complex systems and grounded in career and technical contexts that facilitate multidisciplinary, interdisciplinary, or transdisciplinary learning for the development of life-long and workforce development connections and skills" (Wang & Knobloch, 2022, p. 4).

IN-VISION (Industry-driVEn Integrated STEM and Systems Approach to Innovative InbutatiON): Project "uniquely positioned to advance knowledge about teaching and learning in iSTEM that uses agro-ecosystem thinking situated in agricultural design challenges to develop and practice data-based decision making. The IN-VISION project aimed to provide a meaningful and supportive context in which students can contextualize STEM in their own lives and the lives of others, see the interdisciplinary connections, navigate the deluge of scientific data that is available, and learn through authentic communication of their understandings" (Wang et al., 2021). There were four objectives of the project: "(1) Develop a year-long teacher professional development program to increase rural high school STEM teachers"... "agricultural literacy and teaching capacity; (2) create a small learning community for rural high school teachers to co-develop iSTEM and AFNR educational materials that is solidly grounded in agro-ecosystem thinking; (3) provide scientists opportunities to collaborate with teachers to disseminate their research data and results through Extension/educational events; and, (4) equip rural high school students with critical thinking and problem-solving skills that are essential to success in the 21st century workforce" (Wang & Knobloch, n.d.).

Project-Based Learning: "an active student-centered form of instruction which is characterized by students' autonomy, constructive investigations, goal-setting, collaboration, communication and reflection within real-world practices" (Kokotsaki et al., 2016, p. 267).

Systems Thinking: "A systems thinking approach requires individuals to view the whole (whether problem, system, event, or entity) from multiple perspectives, while recognizing the interactions, patterns, and inter-relationships between the components, and considering the cause-and-effect relationships of the components in terms of temporal and spatial dimensions. Systems thinking is essential for increasing our ability to understand the challenges facing our society today, to develop solutions, and, more importantly, to take action as global citizens" (Sweeney & Sterman, 2007 as cited in Lee et al., 2017, p. 138), and "learning the characteristics of the system's components is not enough, and one must also study the interrelations between them" (Gero & Zach, 2014, p. 1192).

Task Values: "subjective, meaning that the same task can be valued quite differently by different individuals and tasks with equivalent levels of difficulty can be valued quite differently by any one person" (Eccles & Wigfield, 2020, p. 4). Task value is further defined by four components: "*attainment value* (i.e., importance of doing well), *intrinsic value* (i.e., personal enjoyment), *utility value* (i.e., perceived usefulness for future goals), and *cost* (i.e., competition with other goals)" (Leaper, 2011, p. 359).

- ***Intrinsic Value:*** Also referred to as interest value, it is "the anticipated enjoyment one expects to gain from doing the task for purposes of making choices and as the enjoyment one gets when doing the task" (Eccles & Wigfield, 2020, p. 4).

- ***Utility Value:*** conceptualized "in terms of how well a particular task fits into an individual's present or future plans… utility value is related to the idea of extrinsic motivation, because when the [Situated Task Value] of a task is primarily linked to its utility value, the activity is a means to an end rather than an end in itself" (Eccles & Wigfield, 2020, p. 5).

- ***Attainment Value***: "the relative personal/identity-based importance attached by individuals to engage in various tasks or activities… derives from the assumed fit of perceived task characteristics with the individual's core self-schema, social and personal identities, and ought selves; that is, the extent to which tasks do or not allow persons to manifest those behaviors that they view as central to their own core sense of themselves or allow them to express or confirm important aspects of their central selves" (Eccles & Wigfield, 2020, p. 5).

- ***Perceived Cost:*** "every activity or task has costs as well as benefits and that individuals will avoid tasks that cost too much relative to their benefits, particularly when compared to alternative tasks with a higher benefit to cost ratio" (Eccles & Wigfield, 2020, p. 5).

- ***Self-efficacy:*** also referred to as expectancies for success (ESs), "individuals' beliefs about how well they will do on an upcoming task" (Eccles & Wigfield, 2020, p. 3).

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

The chapter covers topics that framed the learning experience within this study including integrated science, technology, engineering, and mathematics (iSTEM), food systems, and systems thinking. This chapter explains the theoretical and conceptual frameworks of this study. The need for this study concludes the chapter.

2.2 Statement of Purpose

The purpose of this study was to describe and explain the relevance students perceived in solving a food system STEM project regarding high school students' self-efficacy, intrinsic value, attainment value, cost value, and utility value upon completion of a food system STEM project.

2.3 Research Questions

1. What were students' intrinsic value, attainment value, and cost value of the food system STEM project upon completion?
2. What were students' utility value motivation (personal & local context) and self-efficacy motivation (cultural & project) before and upon completion of the food system STEM project?
3. What were the relationships among the following variables?
    a. Intrinsic Value
    b. Attainment Value
    c. Cost Value
    d. Personal Utility Value
    e. Local Context Utility Value
    f. Cultural Self-efficacy

2.4 Literature Review Methods

The Purdue University library general and advanced search tool, Purdue dissertations and thesis database, and Google Scholar were utilized to search for references. Search phrases and terms used to find literature included: situated expectancy value theory, utility value, food system education, systems thinking, integrated STEM, task value, high school task value, and agriculture task values. Literature included in the review addressed the following topics: K-12 formal education audience; expectancy value theory and situated expectancy value theory; integrated STEM, system thinking, and project-based learning; food systems and literacy; and motivation and engagement.

2.5 Review of Literature

This study utilized a pre-existing learning experience. The learning experience was implemented in high school classrooms and incorporated a few teaching approaches to help students tackle the real-world challenges. The table below (Table 1) outlines the topics that support the learning experience.

Table 1. Literature Topic Alignment

Project Design	Explanation
Learner-Centered Teaching Approach	The learning experience was learner-centered, specifically project-based learning, giving educators the role of facilitator and students the opportunities to make decisions and choose the direction of the experience (Moore et al., 2020).
iSTEM	An integrated STEM (science, technology, engineering, and mathematics) approach helped students apply skills and content across domains to solve a real-world challenge (Wang & Knobloch, 2022).
Systems Thinking	A systems thinking approach challenged students to view a complex project with different perspectives and to understand the various relationships within a system (Lee et al., 2017; Nagarajan & Overton, 2019; York et al., 2019).
Project Context	**Explanation**
Food Systems	There are many systems within the food system including the economic system, political system, health system, environmental system, social system, and the farming system (Center for Ecoliteracy, 2013), creating many opportunities for students to make connections.
Urban Agriculture	Urban agriculture systems are multi-purposes and look different than traditional agricultural systems because of resource access and other barriers (Knobloch, 2021; Wiskerke, 2015).

2.5.1 Learner-Centered Teaching Approach

Learner-centered teaching (LCT) approaches give students control of their learning and educators become facilitators (Moore et al., 2020). LCT approaches such as problem-based learning, inquiry learning, engineering design, design-based learning, and project-based learning are examples of LCT approaches (Thibaut et al., 2018; Kelley & Knowles, 2016; Moore et al., 2020; Wang & Knobloch, 2018). Project-based learning (PjBL) is a learner-centered teaching inquiry approach that give students autonomy and challenges students to collaborate, reflect, set goals, and engage in social interactions and to do so within an authentic community-based challenge (Capraro et al., 2013). Students have autonomy in PjBL because they get to choose the rigor, direction, and design of their project based on their interests and identities as well as set goals for the project (Capraro et al., 2013; Willems & Gonzalez-DeHass, 2012). Autonomy in

PjBL can improve students' intrinsic motivation (Capraro et al., 2013). Through PjBL students solve real-world problems that are guided by a driving question that students should answer (Kokotskaki et al., 2016). PjBL requires students to develop a concrete result and reflect on the learning process. Project-based learning helps students develop 21st century skills that will prepare them for the workplace (Bell, 2010). "Learning responsibility, independence, and discipline are three outcomes of PBL" (Bell, 2010, p. 40). The role of the educator in PjBL is that of a facilitator, however teacher effectiveness depends on the knowledge of the educator (Capraro et al., 2013; Thibaut et al., 2018).

2.5.2 Integrated STEM

Integrated STEM is "intentionally and purposively blending multiple disciplines (i.e., academic and vocational) to help students meaningfully learn and apply academic content through real-world problems framed in designed complex systems and grounded in career and technical contexts that facilitate multidisciplinary, interdisciplinary, or transdisciplinary learning for the development of life-long and workforce development connections and skills" (Wang & Knobloch, 2022, p. 4). The National Science and Technology Council (2018) identified their goals for science, technology, engineering, and mathematics (STEM) education including the goal to engage diverse students in STEM and to prepare those students for careers in STEM and related fields such as agriculture, and to do so the National Science and Technology Council recommended that STEM be taught with an interdisciplinary approach. STEM integration can vary in the level of integration, length of the activity, and the purpose of integration within the learning (Moore et al., 2020). The different levels of STEM integration and the implementation of iSTEM are affected by the educator's knowledge ability to support learners (Wang & Knobloch, 2018; Kelley & Knowles, 2016). The different levels of iSTEM are multidisciplinary, interdisciplinary, and transdisciplinary (Vasquez et al., 2013). Multidisciplinary integration teaches content within the domains but with a common theme (Vasquez et al., 2013). Interdisciplinary integration teaches similar content from domains together, for example, teaching the science of genetics and the mathematics of probability (Vasquez et al., 2013). Transdisciplinary integration blends the content from various domains to answer or address an essential question or real-world problem (Vasquez et al., 2013). Wang and Knobloch (2018, 2022) developed a rubric that describes the various levels of integration when contextualized within an AFNR context. An iSTEM project must integrate at least two disciplines

(Ortiz-Revilla et al., 2020). There are different opinions on how STEM should be integrated. Some researchers support the integration of the silos early on and others support building a siloed foundational knowledge with integration to follow because the foundations will provide students with knowledge and skills to build upon (Moore et al., 2020; Kelley & Knowles, 2016). The context of iSTEM can also vary. Often, STEM is only integrated within STEM domains, often with focus on science and mathematics leaving out technology and engineering (Kelley & Knowles, 2016). Other disciplines outside of STEM can be used to contextualize content such as agriculture, food and natural resources (AFNR) (Moore et al., 2020).

iSTEM should be taught with real-world problems and contexts (NSTC, 2018; Wang & Knobloch, 2018). Real-world problems span across multiple disciplines and require learners to transfer knowledge across disciplines (Thibaut et al., 2018). STEM disciplines utilize similar skills and have cross-cutting topics (Moore et al., 2020). Authentic real-world problems support students' development of 21st century skills, STEM literacy, and STEM career interests (NSTC, 2018; Kelley & Knowles, 2016; Moore et al., 2020). Within the real-world problems, learners should solve problems relevant to their communities and to global issues and interact with the different perspectives (NSTC, 2018; Kelley & Knowles, 2016). Connecting students to STEM professionals will support student learning (Kelley & Knowles, 2016; Willems & Gonzalez-DeHass, 2012). Because iSTEM is complex, it needs to be made explicit to students (Kelley & Knowles, 2016).

Thibaut et al. (2018) outlined some challenges to iSTEM. The traditional teaching of STEM domains separate from each other means that integration can often require restructuring of lessons and curriculum. Project-based learning and other learner-centered teaching approaches support an iSTEM approach (Wang & Knobloch, 2022), but the materials and resources needed can present a challenge. Lastly, Thibaut et al. (2018) identified the content knowledge and pedagogical content knowledge of teachers as a possible challenge to an iSTEM approach. Currently, there is not a commonly accepted universal definition of iSTEM and effective teaching methods for iSTEM are still being developed and researched (Moore et al., 2020; Kelley & Knowles, 2016).

2.5.3 Systems Thinking

Learners naturally learn content in the respective discipline apart from other disciplines (York et al., 2019). Systems thinking challenges learners to think with a new holistic approach. "A systems thinking approach requires individuals to view the whole (whether problem, system, event, or entity) from multiple perspectives, while recognizing the interactions, patterns, and inter-relationships between the components, and considering the cause-and-effect relationships of the components in terms of temporal and spatial dimensions" (Sweeney & Sterman, 2007 as cited in Lee et al., 2017, p. 138). Further, Gero and Zach (2014) explained, "Learning the characteristics of the system's components is not enough, and one must also study the interrelations between them" (p. 1192). The components of the systems are analyzed as well as the relationships between the components and the organization of the components (Nagarajan & Overton, 2019; York et al., 2019). Charoenmuang (2021) recommended beginning by teaching students about the different processes and making connections within the food system then to challenge students to make bigger connections to other systems. Charoenmuang also recommended teaching students how to explain the systems in detail, especially the cyclic and dynamic nature of the food system. Learners should be challenged to view the system from various viewpoints including the spatial and temporal dimensions (Charoenmuang, 2021). The application of a food system allows all students to bring their own perspective to the project because food involves everyone (Charoenmuang, 2021). Systems thinking can facilitate interdisciplinary education such as integrated STEM (York et al., 2019). Systems thinking within STEM has been reported to increase knowledge retention and develop student problem-solving skills (York et al., 2019). Similar to iSTEM, students should be explicitly informed they are applying a systems thinking approach (York et al., 2019; Charoenmuang, 2021). Because systems thinking does not come naturally, the educator may need to demonstrate systems thinking and help guide students (York et al., 2019).

An authentic complex problem provides a learning context that aligns with system thinking. Systems thinking is more than learning about relationships and interactions, it includes active application of the concepts and learning (York et al., 2019). Systems thinking complements learner-centered teaching approaches such as problem-based and project-based learning (Nagarajan & Overton, 2019). Nagarajan and Overton (2019) identified project-based learning (PjBL) components that support systems thinking. For example, PjBL has a driving question that is open-ended and gives students choice regarding the solutions. Scientific practices should be applied within PjBL and also help students develop 21st century skills and other skills that can help solve global challenges. PjBL incorporates inquiry that is sustained with opportunities for reflection and feedback. Technologies and tools that are used in workplaces are supporting components of PjBL and help prepare students for the workplace. Lastly, PjBL that supports systems thinking produces a final concrete product. Ergo, PjBL requires time, materials and resources, and educator preparation. York et al. (2019) identified professional development about system thinking as essential to support educators when implementing systems thinking. Systems thinking should not be used to replace other teaching approaches, but rather to complement and support them as used in the learning experience (Nagarajan & Overton, 2019).

2.5.4 Food Systems

Every learner interacts with and depends on the food system (i.e., agriculture) every day by consuming food (The National Council for Agricultural Education, 2015). Food is a social practice that everyone interacts with on a daily basis within their cultural values and practices (Barton et al., 2005). However, individuals are disconnected from the food system and have a limited understanding of where their food comes from (Smith et al., 2009). The disconnect creates challenges to solving food related global issues (Bora & Katz, 2019). Food system education has been identified as a step towards the global concern for sustainable food systems because it supports interactions with global food issues and challenges students to solve grand challenges (Meek & Tarlau, 2015; Nanayakkara et al., 2017). However, Meek and Tarlau (2015) clarified the need for furthering food system education curriculum. Meek and Tarlau explained that food system education teaches the processes and problems within food systems and new concepts of sustainability. Teaching about food systems can be challenging because they are complex systems that are always changing and growing (Nanayakkara et al., 2017; Hilimire et al., 2014). There are many factors that influence food systems including environmental factors, current issues, emerging technologies, health concerns, etc. (Meek & Tarlau, 2015). There are also stereotypes, such as those accompanying social economic status, misconceptions, and gaps in understanding that surround food systems must be addressed in education (Earnshaw & Karpyn, 2020; Calabrese et al., 2005).

Within the learning experience of this study, food systems problems encompass any problem from pre- to post- harvest (Hilimire et al., 2014; Nanayakkara et al., 2017). There are systems within the food system including the economic system, political system, health system, environmental system, social system, and the farming system (Center for Ecoliteracy, 2013). The relationships between the components of food systems are complex and span across multiple disciplines (Hilimire et al., 2014). An interdisciplinary and systems thinking approach helps students make connections to prior knowledge, analyze the complex relationships, engage with various system perspectives, and solve food system problems (Hilimire et al., 2014; 2016). Solving food system problems help students develop skills within the domains, 21st century skills, and career skills (Hilimire et al., 2014; Nanayakkara et al., 2017). Reflection is a key component to teaching food systems as it helps students make meaningful connections (Hilimire et al., 2014). Food system education is supported when students engage with the community and community connections are made such as farm-to-school programs (Hilimire et al., 2014; Meek & Tarlau, 2015). Simple exposure to food topics was reported to increase student engagement (Hilimire et al., 2014). Approaches to food system education include exposure, case studies, experiential learning, and cooperative learning (Hilimire et al., 2014). Case studies with either inductive, deductive, or a scenario-based study give students an opportunity to make connections to content and real-world examples as well as apply 21st century skills. Hilimire and colleagues (2014) identified challenges to implementing food system education including financial concerns, educator bias, the interdisciplinary knowledge of the educator, and misconceptions within food systems such as the misconception that food system and sustainable agriculture are synonymous.

Solving food systems problems can also help students develop food literacy. “Food Literacy is a multi-faceted concept that comprises three integrated components: Food, nutrition and health; Agriculture, environment and ecology; Social development and equity” (Bellotti, 2010, p. 23 as cited in Cleland & Baird, 2013, p. 10). Food literacy includes understanding food system concepts from production to consumption to waste as well as the various components that span across disciplines such as economics, environmental pieces, cultural influences, and political and social components (Nanayakkara et al., 2017; Center for Ecoliteracy, 2013). Thus, food as a topic offers opportunities for interdisciplinary education and long-term education can foster student relationships with the food system (Nanayakkara et al., 2017). Food literate citizens can make more informed decisions about food and benefits to their health (Nanayakkara et al., 2017).

2.5.5 Urban Agriculture

The Natural Resources Conservation Service (NRCS), under the United States Department of Agriculture (USDA) (2023) defines urban agriculture as “the cultivation, processing, and distribution of agricultural products in urban and suburban areas” including “community gardens, rooftop farms, hydroponic, aeroponic and aquaponic facilities, and vertical production. Tribal communities and small towns may also be included" (para. 1). Over time consumers have been distanced or removed from food production and are not agriculturally literate (Knobloch, 2021). The food production process has changed over time and involves many more steps, contributing to the distance between consumers and producers. Consumers have responded to this distance by cultivating food in their communities in combination with other motivations such as social justice, environmental and financial sustainability, food access, and cultural food access (Knobloch, 2021).

Urban agriculture naturally engages consumers in a holistic or systems approach. Urban agriculture systems can serve various purposes. Urban agricultural methods are often smaller scale because of resource access and financial barriers (Knobloch, 2021; Wiskerke, 2015). Although the methods often require more hands-on work, innovative approaches that combine systems and create synergies such as aquaponics or compost programs that have been developed to efficiently utilize resources while engaging stakeholders and community members (Wiskerke, 2015). Consumers may be financially motivated to participate in urban agriculture. More affordable food, higher quality food, access to fresh produce, and access to cultural foods are examples of consumer motivations. Urban agriculture can also engage consumers in social justice concerns and sustainability. Because of the inclusive nature of food, it creates opportunities to engage all cultures, all social groups, and all citizens in the many aspects of the food system within urban agriculture (Knobloch, 2021).

2.6 Theoretical Framework

Expectancy Value Theory (EVT) was chosen for this study because it outlines how students' values influence their achievement and their engagement decisions within specific contexts, the outcome variables of the study. EVT is a framework utilized in motivational research to examine engagement decisions of individuals (Gladstone et al., 2022). EVT explains how "individuals' choice, persistence, and performance can be explained by their beliefs about how well they will do on the activity and the extent to which they value the activity" (Atkinson, 1957; Eccles et al., 1983; Wigfield, 1994; Wigfield & Eccles, 1992 as cited in Wigfield & Eccles, 2000, p. 68). EVT was further explored and defined as Situated Expectancy-Value Theory (SEVT) because the variables and the variable relationships within the model are unique to individuals at the specific time of measurement (Gladstone et al., 2022). Individuals' motivation is influenced by their experiences, beliefs, and values as well as their environment at the time of observation. The EVT and SEVT frameworks have been utilized in educational research to explain the relationships between motivational variables and to explain how individuals' beliefs and values influence their motivation and engagement (Wigfield & Eccles, 2000). The theories have been applied to explain engagement in varying domains (Gladstone et al., 2022).

Eccles and Wigfield's (2020) SEVT model frames long-term factors and immediate decision factors. This study focuses on the shorter time frame decision factors, including subjective task values and expectancies for success (ES), also referred to as self-efficacy. Self-efficacy is defined as the personal belief that success is attainable (Bandura, 1977). An individual's perception of their ability to complete a task influences the effort they exert on the activity. Self-efficacy can vary in magnitude, generality, and strength. SEVT refers to self-efficacy as expectancies for success and defines expectancies for success as an individual's perception of how they will do on an immediate or future task (Eccles & Wigfield; Gladstone et al., 2022).

Subjective task values (STVs) encompass the comprehensive value of a task and vary from individual to individual (Eccles & Wigfield, 2020). STVs are not equally weighted by individuals due to individuals' "Developmental processes, situational processes, individual differences, and individual by context processes" (Eccles & Wigfield, 2020, p. 3). Even if the environment and activity is the same, STVs are unique to the individuals. Task value is further defined by four values: intrinsic value, utility value, attainment value, and cost value.

Intrinsic value is the satisfaction or enjoyment one gets from a task that is unique to their interests and personal choices (Eccles & Wigfield, 2020). If an individual has a high intrinsic value, they are more likely to be deeply engaged in the activity, which encourages persistent engagement.

Utility value describes the usefulness of the activity and how students find tasks applicable to their lives (Eccles & Wigfield, 2020). Utility value is often connected to the short-term and long-term goals of an individual (Gaspard, 2015; Eccles & Wigfield, 2002). Individuals could connect the utility value to present goals such as passing the class or future goals such as graduating high school. Utility value could also be connected to personal goals such as future career aspirations. Utility value is often described as an extrinsic motivation.

Attainment value is rooted in a student's identity (Eccles & Wigfield, 2020). Students seek tasks that allow them to engage in behaviors important to their identity. The different types of identity and the alignment with the activity influence the attainment values of individuals. There are many types of identity that individuals may hold including gender identity, social identity, cultural identity, educational identity, career identity, and others.

Cost value describes the trade-offs of an activity (Eccles & Wigfield, 2020). Every activity has costs and benefits for an individual. If an activity has too many costs, an individual will avoid it. The STVs and expectancies for success (ES) are influenced by the long-term factors of the SEVT model including cultural influences, previous experiences, and personal characteristics.

2.7 Conceptual Framework

The conceptual framework was a conceptual model of the independent and dependent variables of the study (Figure 1), which was informed by Eccles & Wigfield's (2020) Situated Expectancy-Value Theory (SEVT). SEVT measures values and beliefs of high school students to understand their motivation and engagement in the classroom. The independent and dependent variables of this study were subjective task values, intrinsic value, utility value, attainment value, and cost value, and self-efficacy from the right side of the SEVT framework. The conceptual framework outlines factors that influence student task values and the context within which they were measured.

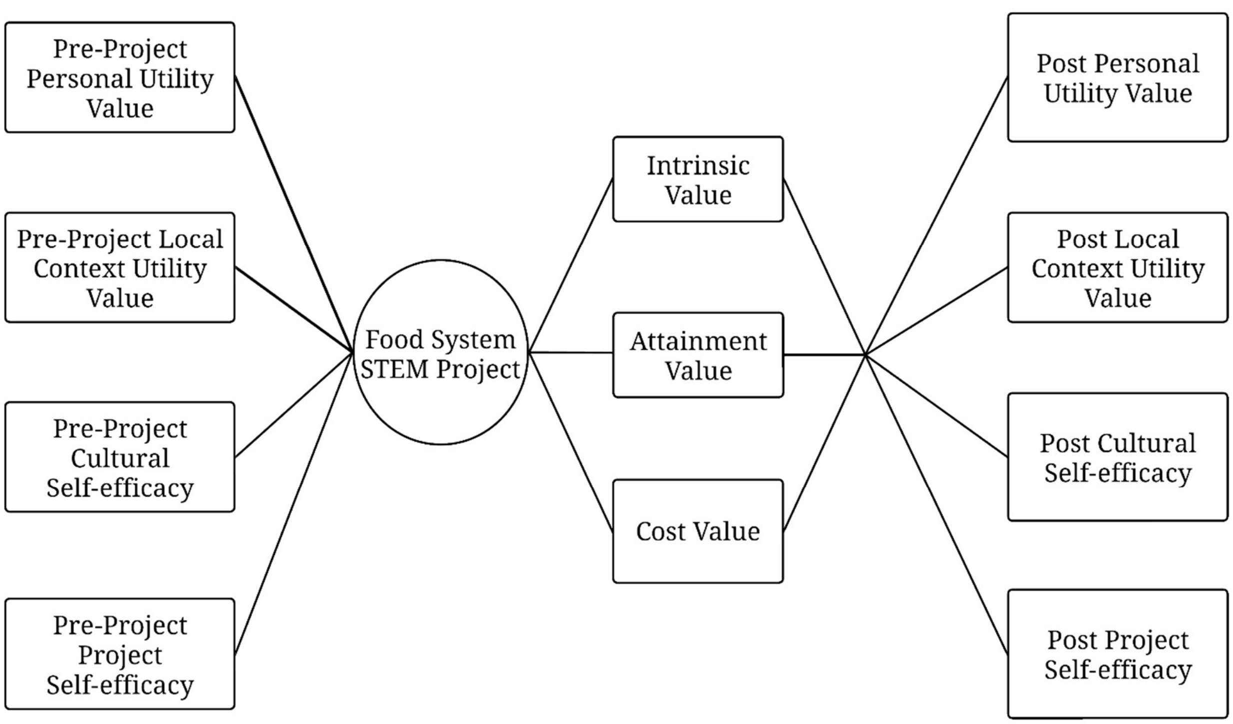

Figure 1 Conceptual Framework

The subjective task values (STV) intrinsic value, attainment value, and cost value are conceptually separated from utility value and self-efficacy because they were regarded as independent variables in this study. Intrinsic value is unique to the student interests and the individual's perception of enjoyment. Attainment value is separated as an independent variable because attainment values are rooted in student identity. Within this study, attainment value focuses on the personal identity and what they perceive as important and does not investigate other types of identity (Eccles & Wigfield, 2020). Cost value describes the tradeoffs of the activity. The cost of a task influences a student's motivation to engage in the activity or learning. Informed by Gaspard et al.'s (2015) study, cost value measurements focused on the effort cost and opportunity costs of the project. Because this is a food system STEM project with many components, the researcher chose to focus on how students valued the effort they put into the project and the opportunity cost or what students felt they were giving up engaging in the project. The independent task value variables were measured upon completion of the project. Researchers found that the task values predict student performance and achievement (Wigfield & Eccles, 2020). The right side of the conceptual framework illustrates the relationships between the task values because they were explored to compare to previous studies that have found positive correlations (Wigfield & Eccles, 2020). Wigfield and Eccles (2020) reported students' task values are impacted by their identities.

Utility value and self-efficacy were separated from the other task values because they were considered dependent variables in this study. The conceptual framework shows the measurement of personal and local utility value and cultural and project self-efficacy retrospectively before the food system STEM project, and upon completion. The framework shows that utility value and self-efficacy are related to the independent variables, intrinsic value, attainment value, and cost value of the food system project. Utility value describes how the individuals find the activity useful and relevant to their goals (Eccles & Wigfield, 2020). Wigfield and Eccles (2020) share that adolescence is when students begin to make connections to the usefulness of their learning. Utility value was broken down to describe the personal utility value and the local context utility value of the project. Informed by Gaspard et al.'s (2015) study, personal utility value measures utility value in respect to the individuals' daily life, future life, and job. The researcher was interested in how students connected the content and experience to their future because of the need to prepare students for the workforce and prepare them for solving local community and global challenges

(United States Department of Education, n.d.). Local utility value describes the usefulness and application of the project to a participant within their community and the community's goals. Self-efficacy was also broken down to describe the cultural self-efficacy of participants and the project self-efficacy. Bandura (2011) stated "judgments of self-efficacy for pursuits like academic achievement, organizational productivity, entrepreneurship, and effecting social change encompass activities of broad scope, not just an isolated piece of work. Moreover, strength of self-efficacy is measured across a wide range of performances within an activity domain, not just performance on a specific item" (p. 17). Self-efficacy beliefs can be described beyond single tasks. Cultural self-efficacy describes a participant's beliefs that they can utilize their cultural identity and experiences to work through the project. Project self-efficacy describes a participant's beliefs that they can complete the tasks needed to complete the project. Personal and local utility value and cultural and project self-efficacy were also collected post project.

The food system STEM project learning experience is the context in which utility value and self-efficacy will be measured. Reflecting the researcher's teaching philosophy, with PjBL students learn by doing and engaging in the project and constructing new knowledge based on their previous knowledge and experiences (Bell, 2010). Learner-centered teaching approaches engage students by giving the students more control and personalization and allow for better development of task values because task values are conditional to the situation and vary among individuals (Bernard et al., 2019; Eccles & Wigfield, 2020). Benefits of PjBL include a reported increase in student engagement and the development of intrinsic motivation (Bell, 2010; Kokotsaki et al., 2016). Kokotsaki et al. (2016) stated that student engagement increased because projects were actively and cognitively engaging with different dimensions that students had to analyze. Bell (2010) shared how the autonomy students have within PjBL helps intrinsically motivate them because they get to choose the direction of their projects based on their interests, thus leading to deeper learning and persistence, which is reflected in the SEVT theoretical framework. The project within this study further developed students 21st century skills by incorporating systems thinking (Nagarajan & Overton, 2019). PjBL also supports the transfer of knowledge across disciplines and helps students holistically understand concepts (Kokostaskaki et al., 2016; Bell, 2010). The implementation of PjBL was complemented by incorporating an integrated science, technology, engineering, and mathematics approach (iSTEM). Integrated science, technology, engineering, and mathematics (iSTEM) and PjBL work together because both challenge students to solve real-world problems, which reflect workplace environments and have crosscutting concepts and 21st century skills (Thibaut et al., 2018; Ortiz-Revilla et al., 2020). Furthermore, students develop communication and collaboration skills by working with their peers and working with stakeholders or their target audience. Working with peers and the stakeholder also helps students develop personal accountability (Capraro et al., 2013; Bell, 2010). An authentic problem requires students to take a transdisciplinary approach and transfer knowledge and skills across disciplines (Thibaut et al., 2018; Ortiz-Revilla et al., 2020). PjBL combined with an iSTEM approach and a real-world context can increase the relevancy of the content (Thibaut et al., 2018). Thibaut et al. (2018) stated that iSTEM should be explicit to help students integrate knowledge and skills across disciplines as well as make connections to their previous experiences and knowledge. The components of the PjBL and iSTEM approach and the independent student value variables come together to influence the development of utility value and student self-efficacy. When students are able to self-generate relevancy of content, they can become intrinsically or self-motivated learners (Bell, 2010).

2.8 Need for Study

Eccles and Wigfield (2020) identified the need to define the dependent variables within Situated Expectancy Value Theory and distinguished the differences in the relationships and descriptions. Studying the relationships between the task values of high school students within a PjBL and food systems context will address the subject gap, the grade level gap for this context, and the geographical gap. Because there are a variety of environmental influences on students' task values, understanding how students respond to the influences and how they impact how they find information relevant is needed (Akcaoglu et al., 2018; Jones et al., 2021). The task values of high school students need to be further described. The authentic experience that PjBL offers students can influence their perceptions and PjBL offers a unique environment to analyze expectancy-value theory variables. Gray (2018) identified the need to conduct studies of task value in diverse economic and social environments as well as social settings.

2.8.1 SEVT Outside Agriculture

Situated Expectancy Value Theory has been applied in other domains to study elementary, middle, and high school students' motivation. Task values have been described within STEM courses and programs. Ball et al. (2017) examined the task values and attitudes in STEM using EVT but at the late elementary level. They examined the relationships between the task values, excluding cost, and self-efficacy of students and their STEM attitudes after a technology focused intervention. The results showed that if the intervention is interesting and useful to the students, it had a positive influence on their attitudes; attitudes can be predicted by the intrinsic and utility value of students. Rozek et al. (2017) explored how a STEM intervention, focusing on extrinsic motivators, affected the utility value of students in relation to their test scores and the pursuit of a STEM career. The findings showed that parents can serve as a source of extrinsic motivation for students. Rozek et al. (2017) concluded that the focus of policy on funding to increase STEM enrollment is not going to address the issue of student motivation and should be further addressed. Jones et al. (2021) focused on the task value of science to middle school students. Jones et al. found that the resources and tools that the students interact with related to science influence their values. The science achievement values, or self-efficacy, and the perceptions of the family science achievement, or the interests and family expectations, affect the students' science task values. Jones et al. explored the environment of learning but did not study the context of the science content. The perceived task values within a middle school mathematics context have been studied by Skaalvik et al. (2017). The study looked at the relationships of task values and classroom goals of high school students to their anxiety, help-seeking behaviors, and effort. The results showed that intrinsic values of students were negatively related to the performance goal structure, however, were positively related to the effort and help-seeking behaviors of students. Utility and cost showed nonsignificant relations to anxiety, help-seeking behaviors, and effort. Skaalvik et al. (2017) found that task value mediated other classroom variables such as anxiety and noted relationships between task value variables. Chow (2012) discussed studies that focused on physical science and information technology sciences and the task values of those subjects to high school students. However, cost value was not included in the study. The study found that the task value of the students was associated with their domain career aspirations. Chow (2012) recommended expanding research about relationships across more subjects.

Outside of the STEM domains, studies have explored task values in sports and English classes. Hulleman et al., (2008) studied the task values and achievement goals of high school football athletes. The intrinsic and utility values of the athletes influenced their motivation. The results showed that utility value was highest for those who had an interest in playing football. In relation to mastery goals, Hulleman (2008) stated "Too many goals might frustrate and even distract the highly interested individual, whereas multiple goals might enable the less interested individual to remain engaged and motivated" (p. 411). Task value mediate the relationship between mastery goals and interest. Hulleman (2008) reported that utility value can be either intrinsic or extrinsic depending on the context. Chou (2021) explored the relationships of task value within an English as a Foreign Language course. Task values are influenced by what Chou (2021) defines as social factors including gender and ethnicity. The study found that the task values of the students were positively related to their achievement, but the social factors of the study were not a significant influence. SEVT has been used to frame studies in a variety of content areas, but the studies focus on task values in relation to other variables. This study focused on describing the task values within a food system context that does not fall within one domain, but rather challenges students to integrated STEM domains.

2.8.2 Motivation in Agriculture

Chumbley et al. (2015) explored student motivation in Ag+STEM context that applied project-based learning approaches. Chumbley et al. (2015) applied Bandura's social cognitive theory to frame student motivation. The results showed that grade motivation and self-efficacy were the most influential factors on student motivation. Students did not foresee their careers involving agriscience and did not believe that agriscience added meaning to their lives. Chumbley (2015) and his colleagues recommended that agriscience be contextualized to motivate students. Chumbley et al. (2015) identified the need to conduct motivation studies in other states and to explore self-efficacy and motivation.

Russel et al. (2009) applied the Expectancy Value Theory to study how educators motivated their students to engage in career development events (CDEs). CDEs are competitive events that students can participate in through FFA. The qualitative study found that the previous experiences of the students affect their values because of previous schemata. Educators used the intrinsic values of students to match students to CDE events and yield a higher utility value. It was reported that the utility value of the events was higher if the CDE content aligned with the classroom content. Russel et al.'s (2009) work discussed the relevance that students see in CDEs because of the focus on life skill development. It was noted that the achievement expectancy or self-efficacy of the students influenced their CDE engagement.

Anderson (2013) explored the motivation of secondary urban agricultural students. Anderson applied Self-Determination Theory (SDT) to frame the study and explore the enrollment, attendance, and academic efforts of the students. Anderson reported students were motivated by autonomy or opportunities for them to make choices about their learning. There was a reported correlation between the attendance motivation and the perceived effort of tasks; self-regulated students may be more likely to see the utility value of the content. Students also make decisions based on their identity. Supporting Rozek et al. (2017), parents were identified as an extrinsic motivator. Recommendations included teacher support implementation strategies and a need to "understand the implications social and cultural experience have on individuals and use this knowledge to create interventions that will now only recruit a diverse population into agriculture, but also keep them in it (Anderson, 2013, p. 213)." Food is a context that can be easily tailored to student cultures.

Schafbuch (2016) applied expectancy value theory (Eccles & Wigfield, 2000) to describe participants' interest, expectancies for success, perceived usefulness, and perceived importance of high school agricultural students. The students were enrolled in agricultural courses but had both agricultural backgrounds and nonagricultural backgrounds. Schafbuch found the students believed they could learn the content, expected to do well, found the content useful and important, and interesting. Although results showed that traditional agricultural students had the highest beliefs, Schafbuch reported that even students with nonagricultural were interested in the class and found the classes interesting. Recommendations from the study include analyzing how students connect their values to their life, career, and other systems.

Thiel and Marx (2019) explored high school student perceptions of 21st century skill development through agriscience research projects. The research supervised agricultural experiences (SAE) required students to identify a problem, state a hypothesis, and test the hypothesis. Framed by Kolb's Experiential Learning Theory, their findings showed that students who participated in the experiential learning were more self-efficacious of their 21st century skills than other students. The 21st century skills described by the study included critical thinking and problem solving, communication and collaboration, creativity and innovation, and social and cross-cultural skills. Theil and Marx recommended increasing generalizability and researching similar structured projects and their influence on 21st century skill development and self-efficacy.

Motivation and self-efficacy have been studied within high school agricultural classrooms, but the studies have not applied SEVT to analyze task values of the students from the students' perspective. The studies analyzed task values in relation to other variables and often excluded cost value. Studying the relationships between the task values and self-efficacy within food systems context will address a gap in the educational content and describe the correlations between the task values within the integrated STEM approach and the food system context that is not domain specific. Furthermore, utility value has not been contextualized to community connections, and self-efficacy has not been connected to cultural identity in the context of food systems education.

CHAPTER 3. METHODS

3.1 Introduction

This chapter provides a summary of the methodology and rationale in this study. This study was descriptive and explanatory in nature and conducted by a researcher with a positivist paradigm. The participants and settings are described, as well as the learning experience, role of the researcher, and threats to validity. This chapter concludes with explanations of the data collection and the data analysis.

3.2 Statement of Purpose

The purpose of this study was to describe and explain the relevance students perceived in solving a food system STEM project regarding high school students' self-efficacy, intrinsic value, attainment value, cost value, and utility value upon completion of a food system STEM project.

3.3 Research Questions

1. What were students' intrinsic value, attainment value, and cost value of the food system STEM project upon completion?
2. What were students' utility value motivation (personal & local context) and self-efficacy motivation (cultural & project) before and upon completion of the food system STEM project?
3. What were the relationships among the following variables?
    a. Intrinsic Value
    b. Attainment Value
    c. Cost Value
    d. Personal Utility Value
    e. Local Context Utility Value
    f. Cultural Self-efficacy

3.4 Research Design

The study was designed using a positivist paradigm and the researcher assumed the world can be observed and described objectively. A positivist approach holds the view that social sciences can apply the same methods and can have the same structure as the hard sciences (Little, 2019). This study applied deductive reasoning and collected quantitative data using a questionnaire, aligning with the positivist paradigm (Little, 2019; Rehman & Alharthi, 2016). The researcher designed the study with the goal of being objective when collecting data (Park et al., 2020). Aligning with the goals of a positivist approach, it was a descriptive and explanatory study that sought to describe the task values and self-efficacy motivation of high school students who completed a food system STEM project and explain the relationships among the variables within the food system STEM project context. The study applied a non-experimental design and focused on one group of high school students who were located in three different high schools. The participants were from a convenience sample; the students were taught by educators who had completed professional development and training on the implementation of the food system STEM project content and pedagogy as part of the INdustry-driVen Integrated STEM and Systems Approach to Innovative IncubatiON (IN-VISION) project funded by the National Institute of Food and Agriculture (NIFA). A Food System Motivation questionnaire with retrospective pretest and post-test items, adapted from existing measurement tools, was given to student participants to measure their task values and self-efficacy motivation upon completion of the project. The demographics of students were also collected using the questionnaire. The researcher assumed the participants understood the function of a questionnaire and the scale of the questionnaire.

3.5 Participants

Participants in this study were high school students in grades 9th - 12th in three high schools in a Midwestern state. The high schools were assigned pseudonyms: High School A, High School B, and High School C. The high schools were all urban schools with varying demographics (Table 2). High School A and High School B were located in Midwest City X. Midwest City X was a metro city with many agricultural businesses including Corteva, Mycogen Seeds, The CISCO, [Midwest City 1] Veneers, PhytoGen, and Advanced Agrilytics (USDA, 2020; Search agricultural companies in Indiana, n.d.). High School C was in Midwest City Y. Midwest City Y was also a metro city and that had many agricultural businesses including Pure Green Farms, Martin's Greenhouse, Symbiotic Ag Products (Search agricultural companies in Indiana, n.d.). Even though Midwest City X had a larger population than Midwest City Y, the cities had similar resident demographics and food insecurity rates (Table 3).

Table 2. School Demographics

School	Total Population [a]	School Race / Ethnicity [a]	FRLP Eligible Students [c]	Geographic Classification [b]
High School A	543	American Indian or Alaska Native (0.0%), Asian (1.8%), Black or African American (38.5%), Native Hawaiian or other Pacific Islander (0%), White (29.7%), Hispanic (23.9%), other (6.1%)	371 (68%)	Metro
High School B	135	American Indian or Alaska Native (0.0%), Asian (0.7%), Black or African American (36.3%), Native Hawaiian or other Pacific Islander (0%), White (51.1%), Hispanic (5.9%), other (5.9%)	84 (62%)	Metro
High School C	1133	American Indian or Alaska Native (0.3%), Asian (0.8%), Black or African American (32.1%), Native Hawaiian or other Pacific Islander (0%), White (32.3%), Hispanic (24.6%), other (9.9%)	596 (53%)	Metro

Notes: FRLP = Free and Reduced Lunch Program

[a] (Indiana Department of Education, n.d.)

[b] (USDA, 2020)

[c] (*School Directory Information,* n.d.)

Table 3. School City Demographics

School	Location	Population	City Demographics [b]	Median Household Income [b]	Food insecurity rate and population [c]
High School A High School B	Midwest City X	882,000 [b] (Metro[a])	White (57.7%), Black or African American (28.8%), American Indian and Alaska Native (0.2%), Asian (3.9%), Hispanic or Latino (10.8%)	$54,321	13.4% (128,270)
High School C	Midwest City Y	103,300 [b] (Metro[a])	White (58.1%), Black or African American (25.2%), American Indian and Alaska Native (0.5%), Asian (2%), Hispanic or Latino (15.8%)	$46,002	13.2% (35,660)

Note: High School A and High School B were both located in Midwest City X.
[a] (USDA, 2020)
[b] (U.S. Census Bureau, 2022)
[c] (Overall (all ages) hunger & poverty in Indiana: Map the meal gap 2022)

Students who attended High School A and High School B completed projects during eight-week cycles. High Schools A and B were project driven schools and the educators held positions of coaches, or facilitators. One of the science educators at High School A taught an eight-week cycle focused on biology and nutrition as energy. Students applied their learning to create a brochure that their peers or someone their age could use to obtain or maintain a healthy lifestyle. Students thoroughly described two diseases that affect youth, the appropriate caloric needs of a youth, examples of healthy foods and a meal plan, three things they learned about health and nutrition, and identified tips for eating healthy when living in a food desert. The other educator at High School A was licensed to teach Advanced Manufacturing and Engineering. Students in that class learned about environmental sustainability and global climate change. Students applied their learning to build hydroponics systems and try to create a solution to challenges created by climate change. Students identified the problems that their projects could help solve, described and designed a solution, carried out their solution, and presented about their experience and learning.

Students at High School B were taught by an educator who was licensed to teach Agricultural Education. Students took a more engineering-design approach to build hydroponic and aquaponic systems. Students worked in groups and identified the problem and possible solutions. When identifying the problem, students described the user and the setting as well as the design requirements. Students reflected on the aquaponics and hydroponics solutions that were already present and then designed and built their system prototypes. Challenges were shared and described by students in their final presentations.

The educator at High School C was a Family and Consumer Science (FACS) educator and focused on the economic and social systems within the food system (Center for Ecoliteracy, 2013). Using a spreadsheet, students explored pricing options for a specific food product. Students then learned about market segmentation and how to identify and the target audience and use methods such as advertising to reach their audience. Applying those concepts, students created a marketing plan to sell bread to raise funds for the FACS club. To wrap up, students tried other apple products to explore other product opportunities. Students tested and compared the flavor of different apple products and identified products that utilized apples that were not the freshest instead of the alternative of wasting food.

3.5.1 Demographics of Participants

There were over 90 students who completed the food system STEM project, however only 63 students completed the Food System Motivation questionnaire. Of the participants, 33 (52.4%) identified as male, 29 (46%) identified as female, no students identified as non-binary or third gender, and 1 (1.6%) preferred not to say. Of those participants none identified as American Indian or Alaska Native, 25 (39.7%) identified as Black or African American, 1 (1.1%) student identified as Asian, none identified as Native Hawaiian or another Pacific Islander, 26 (41.3%) identified as White, and 11 (17.5%) identified as another ethnicity. Of the participants, 35 (55.6%) were freshmen, 24 (38.1%) were sophomores, none were juniors, and 4 (6.3%) were seniors. Regarding high school attendance, 29 (46%) attended High School A, 16 (25.4%) attended High School B, and 18 (28.6%) attended High School C.

3.6 Research Setting

3.6.1 Learning Experience

The students participated in inquiry-design project-based learning within an integrated science, technology, engineering, and mathematics (iSTEM) through agriculture, food and natural resources context (AFNR). The student projects required students to reflect on their core content knowledge from the individual disciplines of science, technology, engineering, mathematics, and agriculture, and apply that knowledge through an integrated approach that blends the application, transferability, and knowledge of the individual silos. The projects were called Incubation Design Challenges (IDCs) in the grant proposal. The IDCs the students completed were within an AFNR context specifically focused on food system problems and were referred to as Food System STEM Projects (FSSP) for this study. Food system problems encompassed any problem from pre- to post-harvest including topics such as hydroponics, aquaponics, and food science. The IDCs required students to identify a real-world problem that they could solve with their project. The student projects had to be innovative. Students had to make connections to their project and local community, potential careers, and personal lives outside of school. Students were to design their project with a specific user of stakeholder in mind. The projects had to be feasible, viable, and desirable to the user, client, or stakeholder the project was designed with in mind. The projects had to be feasible, meaning students could design and build it within a realistic time frame, budget, and with available resources. The student projects had to be viable, meaning students had to consider the challenges, obstacles, and limitations of their user or stakeholder and how to avoid creating more challenges for their user with their projects. With the user, client, or stakeholder in mind, the students had to make their project desirable, meaning attractive, practical, and able to address their needs. Throughout the project, students were challenged to take a holistic approach to the project and the four components of the agro-ecosystem: economic viability, social responsibility, environmental sustainability, and production efficiency (Fresco & Kroonenberg, 1992). The project also required students to analyze the systems thinking relationships in addition to their integrated STEM and agricultural literacy understandings. Students were to collect data and apply the information to their project decisions and revisions. At the conclusion of the project, students presented their IDC projects to scientists and professionals at a showcase event. A rubric

(Nelson & Thies, 2022, Appendix B) was developed to outline the project components for the educators and to review and assign awards for the showcase events.

The participating educators completed nine professional development modules: “Introduction to STEM Integration” (30 minutes), “STEM and Ag Disciplines” (30 minutes), “Role of Culture, Community, and Careers” (30 minutes), “Levels of STEM Integration and AFNR” (30 minutes), “Agroecosystem Thinking Model” (30 minutes), “Assessing STEM” (30 minutes), “Scientific Reasoning” (2 hours), “Food Fraud” (2 hours), and “Place-Based Education” (30 minutes). The educators also engaged in conversations with the supporting scientists and university professionals and reflection activities with the grant project leader and topic experts online and in person. The educators asynchronously completed the modules to prepare them to guide their students through place-based learning, scientific reasoning, using sensors, applying food science and safety, hydroponics basics, levels of integrated STEM, integrated STEM assessment, and agroecosystem thinking. The educators also co-developed content and lessons with different content educators to support the students during the implementation of the food system STEM IDCs, and if they chose, they co-taught the lessons.

3.7 IRB Approval

This study was included under the IRB protocol, *“Land-grant Outreach for Community-based Agricultural Learning for Science, Technology, Engineering, and Mathematics (LOCAL STEM) Project,”* attached in Appendix A. The renewal was reviewed and classified as exempted by Purdue’s Human Research Protection Program and Institutional Review Board (IRB) in 2022. The researcher completed the proper IRB trainings including Social Behavioral Research for Research Investigators and Key Personnel and Responsible Conduct of Research (RCR) Training - Faculty, Postdoctoral, and Graduate Students.

3.8 Instrument

The Food System Motivation Questionnaire was adapted from existing questionnaires to align with the purpose of this study and the conceptual framework. Questionnaires addressing task values were collected and compared against each other. Questionnaires compared were all from studies that collected data from a secondary education sample. The tool selected had a calculated factor analysis for each item and included items for all four task values. The task value questionnaire was adapted and developed to measure intrinsic value, personal utility value, local context utility value, attainment value, cost value, cultural self-efficacy, and project self-efficacy items from existing measurement tools. Items were adapted by the researcher and her mentor and reviewed by an expert panel. Intrinsic value, utility value, attainment value, and cost value items were adapted from Gaspard et al. (2015). Gaspard et al. (2015) conducted factor analysis for all items. Table 4 outlines the questionnaire items, if the items were collected post, retrospectively, ot both, and the original source of the items. Intrinsic value, attainment value, and cost value were collected after students completed the project. Personal and local context utility value and cultural and project self-efficacy were collected with a retrospective pretest and post-test. Utility value and self-efficacy considered dependent variables, and the study was designed to describe what students' utility value and self-efficacy were of the project.

Table 4. Food System STEM Questionnaire

Variable	Number of Items	Retrospective Pre-test	Post-test	Original Source
Intrinsic Value	4		X	Gaspard et al. (2015)
Personal Utility Value	8	X	X	Gaspard et al. (2015)
Local Context Utility Value	5	X	X	Developed by Thies & Knobloch (2022)
Attainment Value	4		X	Gaspard et al. (2015)
Cost Value	7		X	Gaspard et al. (2015)
Cultural Self-Efficacy	5	X	X	Yildirim & Tezci (2016)
Project Self-Efficacy	8	X	X	Semilarski et al. (2021)

Note. The table outlines the questionnaire, when the items were collected, and the original source of the items.

Intrinsic value was measured with four items on the Food System Motivation Questionnaire. The items described students' interest (e.g., "I like solving food system STEM problems") and were adapted from Gaspard et al.'s (2015) intrinsic items.

Seven items described students' utility value; three items were focused on students' utility value as it relates to their daily life or short-term goals (e.g., "Understanding solving a food system STEM problem has many benefits in my daily life") and five items were focused on students' utility value as it relates to future careers and future life or long-term goals (e.g., "Solving a food system problem will be useful in my future career"). Items that described student utility value for school were not included in the questionnaire because they did not align with the focus of this study and had lower factor loading scores. Items that described social utility value were not included in the questionnaire because the items did not align with the purpose or focus of this study and had lower factor loading scores. Five items described the utility value of the project within a local context (e.g., "Solving a food system problem will make food more available in my community"). These utility value items were developed by the researcher and her mentor and utilized similar language to the items adapted from Gaspard et al. (2015).

Four items were adapted from Gaspard's (2015) importance of achievement items to describe students' attainment value (e.g., "It is important to me to be good at solving a food system STEM problem"). Gaspard's (2015) personal importance items were not included because they did not align with the purpose of this study and had lower factor loading scores than the importance of achievement items.

Cost value was measured with seven items; four described the cost value as it related to the effort expended on the project (e.g., "Solving a food system STEM problem is exhausting to me"), and three described the opportunity costs of completing the project (e.g., "I have to give up other activities that I like to be successful at solving a food system STEM problem"). Items describing emotional costs were excluded from the questionnaire because they did not directly align with the purpose of this study and there was concern for managing the length of the questionnaire.

Project self-efficacy was measured with eight items adapted from Semilarski et al.'s (2021) questionnaire. The items described student self-efficacy about the tasks of the food systems project. Five items were adapted from Yildirim and Tezci's (2016) study that described teachers' self-efficacy about multicultural education to describe the self-efficacy of the students to make cultural connections to the food system project. The self-efficacy items described the sources of student self-efficacy within the food system project.

Using the developed Food System Motivation Questionnaire (41 variable items), intrinsic value, attainment value, cost value, utility value, and self-efficacy variable information were collected (see Appendix C). The data were collected post-project with a retrospective pretest conducted for utility value and self-efficacy items. The questionnaire items for situated expectancy task values and self-efficacy motivation variables used a five-point one directional scale for all items: 1 = None / Not at all, 2 = A little, 3 = Somewhat, 4 = A lot, and 5 = Absolutely.

Demographic information concluded the questionnaire (4 items). Demographic information gathered included gender, class, race and ethnicity, and school attended. Participants were given the gender options of male, female, non-binary or third gender, other, and prefer not to say. Class options were freshman, sophomore, junior, and senior. For race and ethnicity, participants' options were American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or another Pacific Islander, White, and other. Lastly, participants selected the schools they attended: High School A, High School B, or High School C.

3.9 Validity

Face validity was established by conducting a field test. Face validity ensured the questionnaire language was clear and provided a valid measurement of the task values and self-efficacy variables. The questionnaire items were given to students who had completed the project previously but were not participants in this study. Content validity was established by a panel of content experts from the disciplines of Agricultural Education, Science Education, and Engineering &Technology Education. The panel was comprised of three faculty members. These individuals were chosen because of their knowledge of motivation, self-efficacy, experiential learning, integrated STEM, design thinking and research methods. Dr. Neil Knobloch and Dr. Hui-Hui Wang were faculty within the College of Agriculture, and Dr. Nathan Mentzer was a faculty member in the College of Education and Purdue Polytechnic Institute. To control the psychometric variables, existing measurement tools were found, analyzed, and adapted to this study. The questionnaire relied on the students' ability to reflect on their experience and learning honestly and accurately. The variables intrinsic value, attainment value, cost value, utility value, and self-efficacy were collected by the questionnaire.

Threats to validity included instrumentation and population validity. The questionnaire was administered upon completion of the projects and the pre-test was administered retrospectively with the post-test. Administering the pre-test retrospectively allows students to have an understanding of the content and skills applied and thus allowing them to judge their baseline motivations and avoid response shift bias (Pratt, 2000). The retrospective pre-project items were the same items as the post project items. The way in which the teacher presented the questionnaire, or any verbal directions or preparations could have influenced the results from the students. Educators were requested to give students class time to complete the questionnaire. The student attitude towards the instrument could affect responses. The characteristics of the schools' scheduling and organization could affect the results for example two schools were on 8-week cycles compared to a semester schedule. Generalizability of the results were limited to the convenience sample.

3.10 Role of the Researcher

The role of the researcher aligned with a positivist paradigm and therefore the researcher had little to no interaction with the student participants (Alharahsheh & Pius, 2020). The questionnaire allowed the researcher to have limited interactions with the sample and minimize bias. The researcher communicated with the educators and delivered instructions regarding delivery of the questionnaire.

3.11 Data Collection

Data were collected using a convenience sample. The questionnaire was delivered electronically using an online survey tool (i.e., Qualtrics). The link and directions were sent to educators and the educators shared the link with their students upon completion of the projects. It was requested of the teachers to give the students class time to encourage competition of the questionnaire. The researcher followed up with email reminders for educators to share the questionnaire link with their students upon completion of the project. This allowed the researcher to have limited interactions with the sample and minimize bias. The responses were collected anonymously and stored within the Qualtrics system. Students had the opportunity to opt out of the data collection.

3.12 Data Analysis

The Food System Motivation Questionnaire provided quantitative data for analysis. Data were analyzed using Statistical Package for the Social Sciences (SPSS) software. Quantitative data were analyzed using descriptive statistics including means and standard deviations. Parametric assumptions of normality, linear relationships, and homoscedasticity were met. Pearson correlation coefficient (*r)* was calculated to measure the relationship between the interval variables. A paired sample t-test was conducted to compare the self-reported utility value and self-efficacy after the project and retrospectively pre-project. Effect sizes were calculated using Cohen's *d* (Table 5) (Privitera, 2018, p. 259). The level of significance for this study was < 0.05 (Privitera, 2018). For data analysis, usable data responses were analyzed. The responses from each school were merged into one SPSS file for analysis.

Cronbach Alpha (α) were calculated to measure scale reliability. Post-hoc Cronbach alpha coefficients were: 0.95 for intrinsic value (4 items), 0.94 for the retrospective pre-project personal utility value (8 items), 0.92 for the post-project personal utility value (8 items), 0.93 for the post-project local context utility value (5 items), 0.94 for the retrospective pre-project local context utility value (5 items), 0.88 for attainment value (4 items), 0.94 for cost value (7 items), 0.96 for the retrospective pre-project self-efficacy of project tasks (8 items), 0.95 for the post-project self-efficacy of project tasks (8 items), 0.94 for the retrospective pre-project cultural self-efficacy (5 items), and 0.94 for the post-project cultural self-efficacy (5 items). The table below (Table 8) shows the alignment between the research questions and the data analyses that were conducted.

Relationships were described using Hopkins' (2002) correlation coefficient descriptors (Table 6). The scale used to describe the relationship strengths (r) is as follows: 0.0 - 0.1 is described as trivial, 0.1 - 0.3 is described as small, 0.3 - 0.5 is described as moderate, 0.5 - 0.7 is described as large, 0.7 - 0.9 is described as very large, 0.9 - 1 is described as a nearly perfect relationship as shown in Table 6. Effect size for Pearson correlation analyses were measured using Cohen's *r*-squared and interpreted using the Cohen's effect size conventions (Table 7) (Privitera, 2018).

Table 5. Cohen’s Effect Size Conventions (Privitera, 2018, p. 259)

Effect Size (*d*)	**Description of Effect**
$d < 0.2$	Small
$0.2 < d < 0.8$	Medium
$d > 0.8$	Large

Table 6. Hopkins (2002) Correlation Coefficient Descriptors

Correlation Coefficient (r)	**Descriptor**
0.0 - 0.1	Trivial
0.1 - 0.3	Small
0.3 - 0.5	Moderate
0.5 - 0.7	Large
0.7 - 0.9	Very Large
0.9 - 1	Nearly Perfect

Note. Descriptors were applied to measure the effect size.

Table 7. Conventions for Effect Sizes of Relationships (Cohen, 1988)

Coefficient	**Descriptor**
.01 – .08	Small
.09 - .24	Medium
> .25	Large

Table 8. Data Analysis by Research Question

Research Question	Independent Variable	Dependent Variable	Scale of Measurement	Analysis
RQ1: What were students' intrinsic value, attainment value, and cost value of the food system STEM project upon completion?	Intrinsic Value, Attainment Value, Cost Value		Interval	Mean, SD
RQ2: What were students' utility value motivation (personal and local context) and self-efficacy motivation (cultural and project) before and upon completion of the food system STEM project?		Personal and Local Context Utility Value, Cultural and Project Self-efficacy	Interval	Mean, SD Paired T-Test
RQ3: What were the relationships among the following variables? a. Intrinsic Value b. Attainment Value c. Cost Value d. Personal Utility Value e. Local Context Utility Value f. Cultural Self-efficacy g. Project Self-efficacy	Intrinsic Value, Attainment Value, Cost Value	Personal and Local Context Utility Value, Cultural and Project Self-efficacy	Interval	Pearson's Correlation

Note. The table shows alignment between the research questions and the data analysis conducted.

CHAPTER 4. RESULTS

4.1 Introduction

Results of this study are presented in this chapter. The findings are organized by the research questions of this study.

4.2 Statement of the Purpose

The purpose of this study was to describe and explain the relevance students perceived in solving a food system STEM project regarding high school students' self-efficacy, intrinsic value, attainment value, cost value, and utility value upon completion of a food system STEM project.

4.3 Research Questions

2. What were students' intrinsic value, attainment value, and cost value of the food system STEM project upon completion?
3. What were students' utility value motivation (personal & local context) and self-efficacy motivation (cultural & project) before and upon completion of the food system STEM project?
4. What were the relationships among the following variables?
    a. Intrinsic Value
    b. Attainment Value
    c. Cost Value
    d. Personal Utility Value
    e. Local Context Utility Value
    f. Cultural Self-efficacy
    g. Project Self-efficacy

4.4 Results for the Research Questions of the Study

4.4.1 Results for Research Question One

Research Question 1: *What were students' intrinsic value, attainment value, and cost value of the food system STEM project upon completion?*

The Food System Motivation questionnaire (Appendix C) measured students' intrinsic value, attainment value, and cost value upon completion of the food system problem. The self-reported student results are depicted in Table 7. Students were "somewhat" (*M* = 2.92, *SD* = 1.12) interested in and found enjoyment in the food system STEM project. Students "somewhat" (*M* = 3.30, *SD* = 1.02) agreed it was important to them to do well on the food system STEM projects. Students agreed "a little" (*M* = 2.38, *SD* = 1.05) that there were costs associated with the food system STEM project such as emotional costs and opportunity costs. The results showed that students perceived some value upon completion of the food system STEM project. For information about the student responses for each item and scale responses, item frequencies are reported in Appendix D.

Table 9. Descriptive Statistics for Task Values Upon Project Completion

	N	Mean	Std. Deviation
Intrinsic Value	63	2.92	1.12
Attainment Value	58	3.30	1.02
Cost Value	59	2.38	1.05

Note. Scale: 1 = None / Not at all, 2 = A little, 3 = Somewhat, 4 = A lot, and 5 = Absolutely.

4.4.2 Results for Research Question Two

Research Question 2: *What were students' utility value motivation (personal and local context) and self-efficacy motivation (cultural and project) before and upon completion of the food system STEM project?*

The Food System Motivation questionnaire (Appendix C) measured students' utility value, personal and local, and self-efficacy, cultural and project retrospectively before the project and upon completion of the food system STEM project. The self-reported student results are depicted in Table 8**.**

The results showed students thought the project was "somewhat" (*M* = 2.70, *SD* = .98) useful for their personal future and career goals retrospectively before the food system STEM project. Students reported they perceived the project had "a lot" (*M* = 3.55, *SD* = 1.04) of usefulness for their personal future and career goals upon completion of the food system STEM project with a significant difference before and after the project (p = <.01, *d* = .80) with a large effect size. Students reported they "somewhat" (*M* = 2.96, *SD* = 1.03) perceived the utility value of the project within their local context retrospectively before the project. Students reported they perceived "a lot" (*M* = 3.62, *SD* = 1.10) of utility value of the project within their local context upon completion of the project with a significant difference before and after the project with a medium effect size (p = <.01, *d* = .66). Students reported they were "somewhat" (*M* = 2.97, *SD* = 1.09) culturally self-efficacious of the food system STEM problem retrospectively before the project. Students reported they were "somewhat" (*M* = 3.43, *SD* = 1.06) culturally self-efficacious of the food system STEM project upon completion with a significant difference before and after the project with a small effect size (*p* = <.01 *d* = .43). Students reported they were "somewhat" (*M* = 2.78, *SD* = 1.09) self-efficacious of completing the food system project tasks retrospectively before the project. Students reported they were "somewhat" (*M* = 2.78, *SD* = 1.04) self-efficacious of completing the food system STEM project tasks upon project completion with a significant difference before and after the project with a small effect size (*p* = <.01, *d* = .47).

Table 10. Descriptive Statistics for Utility Value and Self-Efficacy Before and Upon Project Completion

Variable	Before Project			Upon Completion of the Project					
	N	Mean	*SD*	*N*	Mean	*SD*	*p*	Cohen's *d*	Effect Size
Personal Utility Value	63	2.70	.98	56	3.55	1.04	<.01	.80	Large
Local Utility Value	58	2.96	1.03	52	3.62	1.10	<.01	.66	Medium
Cultural Self-efficacy	58	2.97	1.09	54	3.43	1.06	<.01	.43	Small
Project Self-efficacy	59	2.78	1.09	55	3.33	1.04	<.01	.47	Small

Note: Cohen's d is reported at the individual level. Scale: 1 = None / Not at all, 2 = A little, 3 = Somewhat, 4 = A lot, and 5 = Absolutely.

4.4.3 Results for Research Question Three

Research Question 3: *What were the relationships among participants' intrinsic value, attainment value, cost value, personal utility value, local context utility value, cultural self-efficacy, and project self-efficacy?*

Correlations Among Variables

Pearson's correlation coefficients were calculated to describe the relationships between students' intrinsic value, attainment value, cost value, personal utility value, local context utility value, cultural self-efficacy, and project self-efficacy. Variable item frequencies were reported in Appendix D.

The results showed there were many significant correlations among the task value variables, as shown in Table 8. The variance of variables is shown in Table 9. Students' intrinsic value was positively and moderately correlated with personal utility value (r = .48, R^2 = .23); as student interest and enjoyment increases the connections students made to their life and future goals would likely increase. Intrinsic value was positively and largely correlated with local context utility value (r = .46, R^2 = .21); as student interest and enjoyment increases, the connections the students made between the content learned to the future of their community would likely increase. Intrinsic value was positively and largely correlated with attainment value (r = .67, R^2 = .45); as student interest and enjoyment increases, the perceived importance of the task to the student as related to their identity would likely increase. Intrinsic value was positively and moderately correlated with cultural self-efficacy ($r = .53$, $R^2 = .28$); as student interest and enjoyment increases, students' beliefs that they can connect their learning to their cultural experiences would likely increase. Intrinsic value was positively and moderately correlated to project self-efficacy ($r = .48$, $R^2 = .23$); as student interest and enjoyment increases, students' belief that they can accomplish the project tasks would likely increase. Intrinsic value explained 23% of the variance for student personal utility value, 21% of variance for local context utility value, 28% of variance for cultural self-efficacy, and 23% of variance for project self-efficacy. Therefore, as students' interest and enjoyment of a project increases, students' personal utility value, local utility value, attainment value, cultural self-efficacy, and project self-efficacy would likely increase.

Students' personal utility value was positively and largely correlated with attainment value ($r = .67$, $R^2 = .41$); as students connect their learning to their life and future goals, the perceived importance of the task to the student as related to their identity would likely increase. Personal utility value was positively and largely correlated to cultural self-efficacy ($r = .69$, $R^2 = .48$); as students connect their learning to their life and future goals, the students' beliefs that they can connect their learning to their cultural experiences would likely increase. Personal utility value was positively and very largely correlated to project self-efficacy ($r = .76$, $R^2 = .58$); as students connect their learning to their life and future goals, the students' belief that they can accomplish the project tasks would likely increase. Therefore, as students' personal utility value increases, or the more value they see in a project in relation to their life goals, there would likely be an increase in their attainment value, cultural self-efficacy, and project self-efficacy. Students' local context utility value was positively and moderately correlated to attainment value ($r = .47$, $R^2 = .22$); as the connections made between the content learned to the future of their community increase, the perceived importance of the task to the student as related to their identity would likely increase. Local context utility value was positively and very largely correlated to cultural self-efficacy ($r = .75$, $R^2 = .56$); as the connections made between the content learned to the future of their community increase, students would more likely believe that they can connect their learning to their cultural experiences. Local context utility value was positively and largely correlated to project self-efficacy ($r = .69$, $R^2 = .48$); as the connections made between the content learned to the future of their community increase, so students would be more likely believe they can accomplish the project tasks. Therefore, as students' local context utility value increases, their attainment value, cultural self-efficacy, and project self-efficacy would likely increase.

Students' attainment value was positively and largely correlated to cultural self-efficacy ($r = .52$, $R^2 = .27$) and project self-efficacy ($r = .58$, $R^2 = .34$); as the importance of the task to the student as related to their identity increases, students would more likely believe that they can connect their learning to their cultural experiences. Attainment value explained 46% of the variance for personal utility value, 22% of variance for local context utility value, 27% of variance for cultural self-efficacy, and 34% of variance for project self-efficacy. Therefore, as students' attainment value increases, their cultural self-efficacy and project self-efficacy would likely increase.

Students' cultural self-efficacy was positively and largely correlated to project self-efficacy ($r = .86$, $R^2 = .74$); as the connections made between the content learned to the future of their community increase, students would more likely believe that they can accomplish the project tasks. Therefore, as students' cultural self-efficacy increases, their project self-efficacy would likely increase. Students' cost value was not correlated to intrinsic value ($r = .16$, small, negative), personal utility value ($r = .13$, small, negative), local context utility value ($r = .06$, trivial, negative), attainment value ($r = .03$, trivial, negative), cultural self-efficacy ($r = .09$, trivial, negative), and project self-efficacy ($r = .03$, trivial, negative).

The results showed there were moderate to very large relationships between all variables except cost value. Cost value has a small to trivial inverse relationship with all the variables and did not provide an observable pattern.

Table 11. Pearson Correlations Among Post-Project Variables

Variables	Intrinsic Value	Personal Utility Value	Local Context Utility Value	Attainment Value	Cost Value	Cultural Self-efficacy	Project Self-efficacy
Intrinsic value	-						
Personal Utility Value	.48**	-					
Local Context Utility Value	.46**	.81**	-				
Attainment Value	.67**	.64**	.47**	-			
Cost Value	-.16	-.13	-.06	-.03	-		
Cultural Self-efficacy	.53**	.69**	.75**	.52**	-.09	-	
Project Self-efficacy	.48**	.76**	.69**	.58**	-.03	.86**	-

Note. This table shows all the variable relationships in this study. ** Correlation is significant at the 0.01 level (1-tailed)

Table 12. Cohen's R Squared Effect Sizes Among Post-Project Variables

Variables	Intrinsic Value	Personal Utility Value	Local Context Utility Value	Attainment Value	Cost Value	Cultural Self-efficacy	Project Self-efficacy
Intrinsic value	-						
Personal Utility Value	0.23	-					
Local Context Utility Value	0.21	0.66	-				
Attainment Value	0.45	0.41	0.22	-			
Cost Value	0.03	0.02	0.00	0.00	-		
Cultural Self-efficacy	0.28	0.48	0.56	0.27	0.01	-	
Project Self-efficacy	0.23	0.58	0.48	0.34	0.00	0.74	-

Note. This table presents the coefficients of determination. Small effect size = .01 - .08, Medium effect size = .09 - .24, Large effect size = > .25

CHAPTER 5. CONCLUSIONS AND DISCUSSION

5.1 Introduction

This chapter presents the four conclusions from this study, the implications for practice, the limitations of this study, and the recommendations for future studies. The implications of conclusion 2 and conclusion 3 are discussed together following the discussion of conclusion 3.

5.2 Statement of Purpose

The purpose of this study was to describe and explain the relevance students perceived in solving a food system STEM project regarding high school students' self-efficacy, intrinsic value, attainment value, cost value, and utility value upon completion of a food system STEM project.

5.3 Research Questions

1. What were students' intrinsic value, attainment value, and cost value of the food system STEM project upon completion?
2. What were students' utility value motivation (personal & local context) and self-efficacy motivation (cultural & project) before and upon completion of the food system STEM project?
3. What were the relationships among the following variables?
    a. Intrinsic Value
    b. Attainment Value
    c. Cost Value
    d. Personal Utility Value
    e. Local Context Utility Value
    f. Cultural Self-efficacy
    g. Project Self-efficacy

5.4 Conclusion 1

High school students were somewhat interested and felt it was important to do well in completing the food system STEM project.

5.4.1 Discussion

Regarding intrinsic value, students who completed the food system STEM project reported they enjoyed the project and enjoyed solving food system STEM problems. The students reported they were interested in solving the food system STEM problem and enjoyed dealing with food system problems. Regarding attainment value, students reported that it was important and meant something to them to be good at solving the food system STEM problem. Project performance and good grades were important to students that completed the food system STEM problem. Students self-reported there were not large costs associated with the project.

This conclusion supported previous studies that have reported student motivation to participate in and complete agricultural projects. Students' interests in learning about the food system STEM challenge supported Kornegay's (2021) study that found middle school students who participated in an Agri+STEM experience were interested and saw value in the food system. The results aligned with Chumbley et al.'s (2015) study that described agricultural science as a project-based contextualized approach with secondary students and found students were interested in learning about agricultural science. This conclusion also supported Scherer's (2016) conclusion that high school students in a summer precollege agriculture program were interested in the program's agricultural STEM activities. Moreover, the students in our study found the food system STEM problem fun and enjoyable which aligned with Russel et al.'s (2009) findings that students were motivated when teachers made activities and competitions fun and enjoyable. However, there are studies that have found not all students feel they belong in STEM courses and therefore do not have high interest or motivation in the activities (Chubin et al., 2005; Frenzel et al., 2010 as cited in Kornegay, 2021) and not all students are interested in agriculture (Scherer, 2016; Ortega, 2011, Pettigrew, 2018 as cited in Kornegay, 2021). The results did not support Russel et al.'s conclusion that activities were accompanied by costs. The reported attainment value of students supported the findings of Jones et al. (2021) whom studied a STEM problem in a science class. Students also reported they would have to give up their free time, supporting Chumbley et al.'s findings that students were not motivated if class preparation was time consuming.

5.4.2 Implications

When considering Conclusion 1 of this study, there are two implications for secondary education teachers: (1) food system STEM projects do not come with large costs to the students, and (2) the food systems context can be used to motivate students.

The food system STEM project is a tool to engage high school students in learning because while students did report costs of the project, they only agreed "a little." Because the cost was not high for students, students should engage in the project instead of avoiding the project. The cost items showed that students found the project a little exhausting and draining. Perhaps structuring check-in points or breaking the project into smaller pieces could further mitigate the cost of the project. A food systems STEM project that motivates students can provide an environment for students to develop and apply their systems thinking skills; Charoenmuang (2020) reported that motivated students engaged in a food systems education experience demonstrated systems thinking.

With a focus on food, the food system problem revealed many different ways that students can find interest in the project. The combination of teaching using food and an integrated STEM approach created opportunities for students to see even more connections and interesting opportunities. Students can be intrinsically motivated when the interest hook in combination with the project-based learning approach is present (Bell, 2010; Kokotskaki et al., 2016). The relevance and context of food allows all students to come to the classroom with previous experiences because everyone interacts with food on a daily basis within their cultural values and practices (Barton et al., 2005). Knobloch et al. (2007) found that elementary and junior high teachers see the "situatedness, connectedness, and authenticity (p. 32)" of an agricultural context when they integrate it into academic subjects. When students can connect their learning to their identity, it plays to their attainment value and the importance they see in the project.

5.5 Conclusion 2

High school students reported higher personal and local utility value motivation after completing the food system STEM project.

5.5.1 Discussion

Students reported they saw more connections between their personal, future, and career goals after completing the food system STEM project. Specifically, they connected the application of the project to their daily lives. Students recognized the future benefits of a good grade on the project. They thought the project introduced them to potential careers and thought solving the project would help them in their future careers. After completing the food system problem, students understood there were connections to their community within the project. For example, solving the food system problem has the potential to help students see solutions to make healthier food more available and affordable in their communities, and the project has the potential to help students see solutions to make their community a more environmentally sustainable place.

This conclusion supported previous studies that have examined how students are motivated to engage in the classroom. Hulleman (2008) reported that utility value can be either intrinsic or extrinsic depending on the context. The personal utility value items showed that students were motivated by the project as it related to their goals. For example, students could have been intrinsically motivated because the knowledge and skills help students be more autonomous and align with their interests, or they could have been extrinsically motivated because the project was preparing them for future goals. The local context utility value items described how the communities can serve as an extrinsic motivator to students (Willems & Gonzalez-DeHass, 2012). For example, students could have been motivated to complete the project because it would produce healthier food for the school cafeteria or praise from the community for improving food access (Smith et al., 2019). Student responses showed that students saw the relevance of the project regarding their short-term goals, or daily lives, and their long-term goals such as those related to career choices. Anderson (2013) stated that students who did not have an identity in agriculture were still motivated by the extrinsic utility value of a project and its relevance to their high school transcript; similarly, the responses of this study showed that students valued a good grade on the project. Students reported the skills applied in the project would help them in their lives, aligning with Charoenmuang's (2020) claim that food systems education can develop interdisciplinary skills and problem-solving skills. Students saw the utility value of sustainability concepts as it fit within their community which addressed the concerns of Harmon et al.'s (2006) panel that identified the need for youth to understand food systems within their community context and to understand food system sustainability.

Even though the students who responded were from different urban communities, students reported higher local utility value upon completion of the projects. The agricultural businesses within the city and school neighborhoods were different (see section 3.5). The communities had similar food insecure populations and rates (see section 3.5). Regardless of the situation and project, students reported they were able to make relevant connections to their local communities. Students from the different schools reported making connections to food access, affordability, nutritional benefits, and sustainability concerns. The local context engages students in more aspects of the food system such as the health system, social system, and the economic system (Center for Ecoliteracy, 2013).

5.6 Conclusion 3

High school students were somewhat self-efficacious in completing the project tasks and completing the project tasks as informed by their cultural identity and experiences.

5.6.1 Discussion

Students reported making connections beyond the classroom and career preparation; they connected the food system STEM project to their cultural identity and experiences. For example, students agreed they could understand how food helped them understand their traditions and culture and how their culture influenced the food choices they made. Students believed they could identify food system STEM problems that could be solved. They also believed they could design solutions to those problems. Additionally, students believed they could identify the stakeholder or user of the project and could describe their needs. Regarding the iSTEM approach, students reported they believed they could apply science, technology, engineering, and mathematics to solve the food system STEM project (Moore & Smith, 2014; Interagency Working Group on Convergence Federal Coordination in STEM Education Subcommittee Committee on STEM Education, 2022). Looking at career connections, students believed they could connect the project to potential careers, such as a food scientist, a hydroponic grower, horticulturist, and an agricultural engineer.

This conclusion supported previous studies that examined self-efficacy in high school students. The results aligned with Chumbley et al.'s (2015) findings that students were motivated by their beliefs that they could understand the agriscience content and do lab and agriscience project tasks. The tasks of the food system STEM project included 21st century skills such as critical thinking or problem-solving skills, communication and collaboration, creativity and innovation, technology skills, and knowledge construction (Stehle & Peters-Burton, 2019; Thiel & Marx, 2019). Students perceived solving food system problems helped them develop skills within the domain, 21st century skills, and career skills (Hilimire et al., 2014; Nanayakkara et al., 2017). Thiel and Marx (2019) concluded that agricultural research projects influenced the task or skill self-efficacy of students and aligned with students' beliefs that they could solve the food system STEM problem. Barton et al. (2005) advocated for the implementation of food system STEM projects to motivate urban students because all students eat and have previous experiences with food. As such, the results of this study showed that students reported making cultural connections between the project and their previous cultural experiences. The food connection likely helped students find relevance in the project. The food system STEM project provided students with an opportunity to develop their cultural identity and supported Spencer et al.'s (2020) claimed that contextualization within the community allows students to see themselves as a member of the community and an agent of change. This study served as a starting point to address Anderson's (2013) recommendation to "understand the implications social and cultural experience have on individuals and use this knowledge to create interventions that will now only recruit a diverse population into agriculture, but also keep them in it (p. 213)." This study showed that a food system STEM project learning experience can be a tool to motivate students through culturally relevant content but did not evaluate the effect on student retention.

This conclusion supported Bandura's (1994) self-efficacy theory. Bandura (1994) identified four sources of self-efficacy, mastery experiences, vicarious experiences, social persuasion, and the physiological and emotional state of a person. This study showed that students believed they could apply previous experiences with food to solve the food system STEM project. Students believed they could accomplish the tasks; thus, the food system STEM project likely served as a mastery experience for students. Success in high school experiences prepare students for career experiences because students have prior master experiences to build and reflect upon (Oettingen, 1995; Bandura, 1994).

5.6.2 Implications for Conclusion 2 and Conclusion 3

When considering Conclusion 2 and Conclusion 3 of this study, there were four implications for secondary education teachers: (1) a food system STEM project can be a culturally responsive teaching approach; (2) a food system STEM project can help students connect their learning to their lives and explore careers; (3) a food system STEM project can help students develop 21st century skills for life and career preparation; and, (4) contextualizing a project within the community or a specific audience can motivate students.

Culturally responsive teaching intrinsically motivates students (Knobloch, 2021d). A learner-centered teaching approach such as the food system STEM project that includes a piece that can culturally engage students can build an inclusive classroom with motivated students. This study showed that there are a variety of ways to incorporate cultural experiences into the food system STEM project because food has many cultural connections and representations (Cooper, 2013). For example, students could examine how their cultural identity (encompassing aspects such as socio-economic status, religion, ethnicity) influenced their food choices (Enriquez & Archila-Godinez, 2021). Analyzing the needs of a culturally diverse audience would require students to reflect on their own identity and make connections or distinctions between other cultures and society (Milner, 2010). Students could also apply their own cultural experiences to solve and understand problems, and students could use their learning to understand their traditions and culture. The holistic approach of a food system STEM project required an interdisciplinary approach and created opportunities for more cultural connections.

The focus of food within the food system STEM project can help all students connect their learning to their lives because everyone interacts with food daily within their cultural values and practices (Barton et al., 2005). Several examples come to mind. First, students may make connections based on their daily nutritional value or thinking about where their food comes from (Wolsey & Lapp, 2014). Second, students may make connections through a STEM domain including the science behind plant and animal growth, technology behind collecting data or harvesting, engineering behind structural designs or packaging, and mathematics in finances, fertilizer ratios, or data comparisons. Finally, students may make connections based on previous experiences such as previous gardening experiences or a visit to an apple orchard (Bada & Olusegun, 2015). Because of the systems thinking approach, students were challenged to look at the project with a broader interdisciplinary lens, and thus students were exposed to more real-world career connections. Not only can educators implement a food system STEM project to expose students to more career connections, but it can also help prepare students for future careers through skill development (Charoenmuang, 2020). The skills developed, such as the ability to transfer skills between domains, problem-solving skills, justified decision making skills, communication, collaboration, and critical thinking skills, are not only relevant to career goals, but also beneficial to the students' daily lives (Semilarski et al., 2021; Charoenmuang, 2020). A food system STEM project can likely help students connect their learning to their lives through skills that they find relevant to their lives and careers.

Solving a food system STEM project helps students develop 21st century skills that prepare them for their futures. Problem-solving and critical thinking skills will be used by students regardless of the career field they entered (Semilarski et al., 2021). Critical thinking skills are universal and are applied daily (Tunjungsari & Takwin, 2021). Creativity and innovation are applied when students design, build, and redesign solutions (Anwar et al., 2012). In a world of information and ideas, students need to be innovative to not only stand out to employers but also to solve unique problems such as sustainability. Innovation and creativity also help students to make continuous improvements. The food system STEM project as a group project engaged students to develop collaboration and communication skills. Students must learn how to listen to others, evaluate other ideas, give respectful feedback, and share their own ideas. Communication skills were further applied within a food system STEM project when students presented their final projects and explain their process and development. The project created opportunities for students to develop various literacy skills. First, for example, agricultural literacy could be developed through applying a systems approach to understand the relationships of food and other industry aspects within the community, nation, and world (Kovar & Ball, 2013). Second, technology and engineering literacy could be developed through data collection, design evaluation and sensor and software application (Firman et al., 2015; Turiman et al., 2012). Third, science literacy could be developed through decision making based on the results and facts (Turiman et al., 2012), and fourth, mathematics literacy could be developed through data analysis or fertilizer calculations (Ojose, 2011). As such, 21st century skills are transferrable to other domains and applied daily (Semilarski et al., 2021).

Challenging students to think about the food system STEM project within their community helps students to find value and usefulness, beginning with the way the facilitator describes community. The definition of community is shaped by beliefs, values, traditions, and experiences (Clark, 1973; Chavis & Lee, 2015). People belong to multiple communities (Chavis & Lee, 2015). Community could be described as their school system and students could learn how their project could produce and support the food system within the school from seed to composting. Community could be described as a defined local area with a targeted user or stakeholder to challenge students to address specific community needs or concerns. There are various ways that students could find the relevance of their project to their community. Financial applications of the project could be explored; for example, students could analyze the costs of inputs and outputs of a specific food system solution or compare the costs of their designs to their peers' designs. Food access within their community can also create a connection point between students and their projects. Furthermore, fresh produce access can be another connection between the project and the community. Contextualizing the project also supports the interdisciplinary STEM integration (Nikitina, 2006).

5.7 Conclusion 4

Intrinsic value and attainment value motivation were related to utility value and self-efficacy motivation.

5.7.1 Discussion

There were 15 significant relationships that emerged from this study, which supported the conceptual framework of the study (Figure 2). Only the eight relationships between the dependent and independent variables will be discussed to highlight the relationships among the independent and dependent variables. Intrinsic value, or interest and enjoyment, was related to students' personal utility value and local context utility value. Interest and enjoyment in the activity helped them see the relationship to their daily lives and future goals. For example, students were interested in the skills developed through the project. Students also enjoyed the introductions to different careers. Interest was captured by the relevance to their community. For example, students were interested in solving a food system STEM problem that would help design solutions to make healthier food more available and affordable to their community. Additionally, students enjoyed solving a problem that could make their community more environmentally sustainable.

Students' intrinsic value was related to their cultural self-efficacy and project self-efficacy. Students believed they were more likely to apply their cultural experiences and identities to complete the project because they were interested and enjoyed the project. Students were more likely to understand the project connections to their cultural identities and experiences because they enjoyed and were interested in the project. Enjoyment and interest were also related to students' beliefs they could do the project tasks. Students were more likely to believe they could identify and design a solution, identify a stakeholder and their needs, apply science, technology, engineering, and mathematics, and make career connections because they enjoyed and were interested in the food system STEM project.

Next, students' attainment value was related to their personal and local context utility value. Perceived importance of the project was related to the connections students made to the project benefits and their community. Students may have perceived the project as important because it was related to their identity and recognized the connections and benefits of the project to their daily life and future life. Students that believed it was important to be good at solving the problem and to do well solving the problem were more likely to see the relevance to their future goals and community goals. There was a stronger relationship between their attainment value and their personal utility value than their local context utility value. The future goals of students could be rooted in their identities, which supports the relationship that emerged (Gladstone et al., 2022).

Attainment value was also largely related to students' cultural and project self-efficacy. The perceived importance of the project was related to the beliefs that students were confident in their ability to complete the project tasks. A project of importance likely helped students believe they could design, build, and solve a food system STEM project. Activities that allowed students to find importance based on their identity were related to the beliefs that students could apply their cultural experiences and identity to understand and solve the food systems STEM problem.

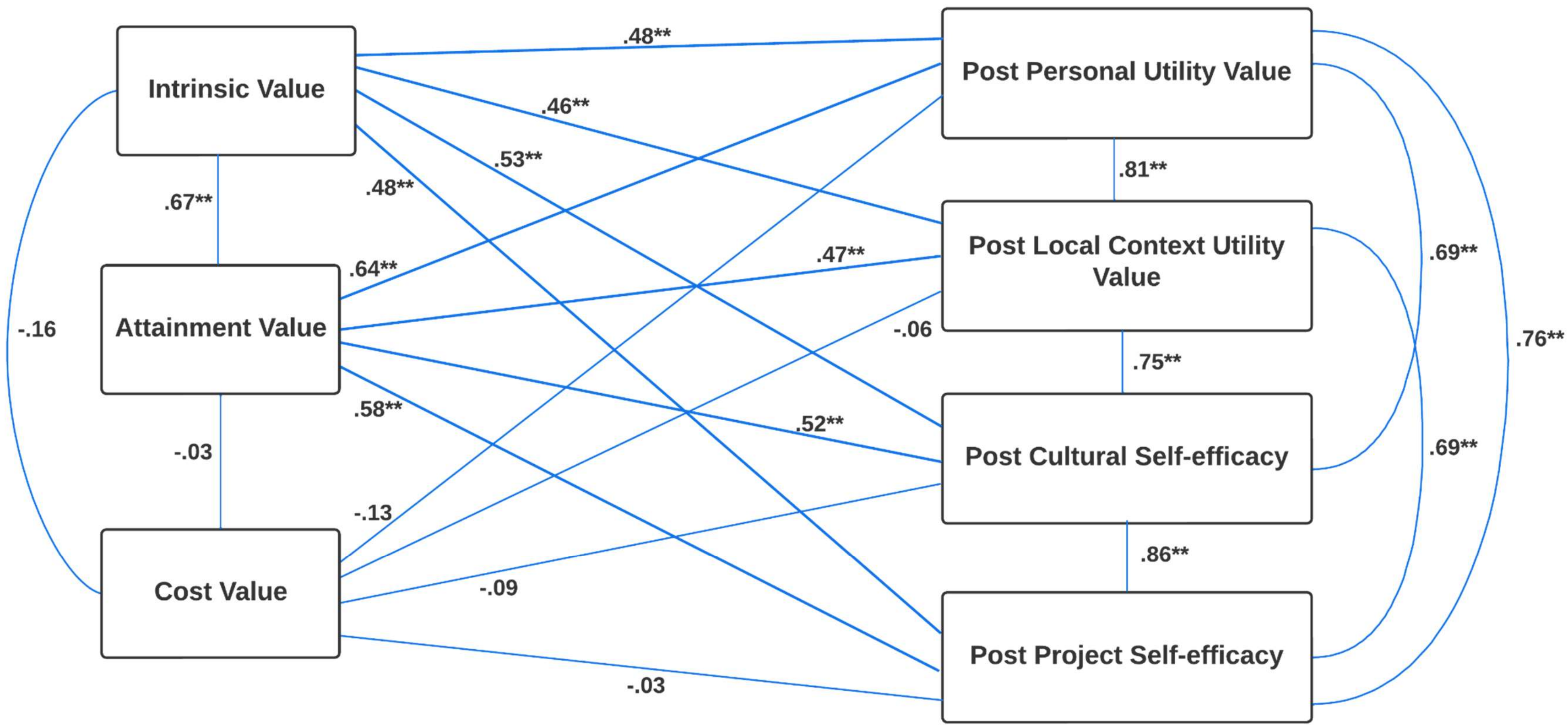

Figure 2 Correlations Among the Post-Project Variables

The relationships that emerged aligned with the conceptual framework of the study (see Chapter 2, section 2.6 Figure 1**)** as informed by Situated Expectancy Value Theory (Eccles & Wigfield, 2002; 2020). The conceptual framework showed the context and design of the food system STEM project would be interesting, important, and accompanied by some costs that would then be related to the utility value and self-efficacy of the students. The results aligned with the conceptual framework and showed the food system STEM project was interesting and important to the students and the interest and project importance were related to student utility value and self-efficacy. Gladstone and colleagues (2022) explained that within SEVT, task values are subjective and unique to the individual, task, and domain. The results supported the implementation of a food system STEM project to motivate individuals through the individuals' interests, the tasks, and various domains through the systems and integrated STEM approach. Reflecting Wang and Eccles's (2013, as cited in Gladstone et al., 2022) results, students with high attainment and intrinsic value were engaged in school. The quantitative results of the food systems project with an iSTEM approach supported the results of Fredricks et al. (2018, as cited in Gladstone et al., 2022) who "found that participants reported feeling more engaged when they saw the relevance of what they were doing in their math and science class" (p. 66). Furthermore, Fredericks et al. (2018) found participants felt more engaged when they perceived they could solve challenging problems using math and science and when they saw "how it could be applied to their lives outside of class" and "demonstrate their ability to their teachers," and "when they felt they could be successful in their math and science classes" (p. 66).

Motivation is affected by different factors including cultural factors (Gladstone et al., 2022). Building on Gaspard's (2015) previous expansion of utility value, the addition of describing local context utility value adds to the body of knowledge surrounding SEVT and factors influencing motivation. Students not only make connections to their daily lives, jobs, and future lives, but they make connections beyond themselves to their communities and global goals. The expansion of utility value to describe the values within a local context and the expansion of self-efficacy to describe the role that cultural identity and experiences play supported Gladstone et al.'s claim. Future goals of students can be rooted in their identity as a member of society (Gladstone et al., 2022). The results of the expansion of utility value described how the food project could be a starting point to address Jones et al.'s (2021) identified need to apply pedagogical approaches that involve community and family engagement. Describing self-efficacy as cultural and project self-efficacy added to the body of knowledge because it showed students believed they could apply their cultural identities and experiences in different contexts (Briones, 2009). The cultural identities of students shape the previous mastery experiences they have had, for example, the socioeconomic status of a family or the community may limit the access to supplies or resources that would support a mastery experience (Oettingen, 1995). The cultural identity of students also shapes the vicarious experiences of students. For example, if a student grows up in the city, there may be fewer opportunities for a student to see large scale farming. The cultural identity of students could influence their vicarious experiences because the models do not share cultural qualities with the students (Oettingen, 1995). The cultural norms or expectations of cultures influence the beliefs of students, for example, if a career as a horticulturist is considered an acceptable career by a student's cultural circle, the self-efficacy of that student could be influenced by approvals or social persuasions (Oettingen, 1995). Some components of cultural identity are described by Eccles and Wigfield (2020) as cultural milieu, as shown on the left side of their expectancy value model, further supporting the connections between the long term and short-term components. The relationships between personal and local utility value and cultural and project self-efficacy were all practically significant. Student goals, personal and as they related to their communities, were largely related to their self-efficacy, both cultural and project.

5.7.2 Implications

When considering Conclusion 4 of this study, an implication to secondary educators is to design a project that targets the interests and identities of students. A project such as the food system STEM project does so and can help students find the relevance in Ag+STEM content to their goals and may increase students' self-efficacy.

Some people may think agriculture is a farmer in front of his red barn with a field of cattle and corn. The agricultural industry is surrounded by stereotypes that may make urban students feel distanced or uninterested in agriculture (Costello, 2018). Urban agriculture looks different than rural agriculture but is just as diverse with and accompanied by the need to develop agricultural literate consumers (Knobloch, 2021). Completing a food system STEM project can make Ag+STEM content more relevant to students, including urban students. The systems thinking within the food project takes a step back to view food through a holistic view or a holistic view of a specific system within the food system such as the biological system, economic system, health system, political system, or social system (Center for Ecoliteracy, 2013). Educators can use their knowledge of their students' interests to design projects that may motivate them and relate to their goals and that they believe they can do. Students could find relevance in the biological system through the global concepts of climate change or composting. Economic system interests could stem from connections to their favorite food companies or their local farmer's market. Introducing global, national, or state policies presents unexpected connection opportunities. To connect to students interested in global safety or health and wellness, the health system provides various connections. In today's world of technology, the social system can be a way to interest students through social media, cultural aspects, or food access on various levels from their own home and community to a global scale. Complementing the systems thinking, integrated STEM helps students make interdisciplinary connections (Wang & Knobloch, 2022). Students could also make relevant connections to STEM content they have previously learned as well as build on their existing STEM knowledge and skills. Moreover, educators can use their knowledge of students' interests and identities to design projects that will be relevant to students and motivate them to engage (Schussler, 2009; Green, 2015).

5.8 Recommendations for Future Research

Based on the results of this study, areas of recommendations for future research include research design, participants, and learning experience implementation. First, the study utilized a small convenience sample that limited the generalization of the results to only students taught by the trained educators. The results are limited to the urban students who were taught by trained teachers and completed the food system STEM project. Future research should continue to utilize the questionnaire to increase the construct validity of the instrument. Confirmatory factor analysis should be conducted with a larger number of participants. The explanatory and descriptive nature of this study also limit the conclusions. It cannot be said that participation within the food system STEM project causes higher motivation or that a food system STEM project is better than another project design. Researchers should conduct causal research (i.e., quasi-experimental design studies) to determine the influences of the food system STEM project. It needs to be explored if it is the food context or the design of the project that motivated students. Future research should also explore the effect that the length of the project or the variations in the school structures has on students' values and motivation. To increase generalizability, this project should be implemented and studied in other urban schools, rural schools, and students taught by various domain teachers.

The quantitative design of this study limited the conclusions made about specific sources of motivation of students such as external motivators. Researchers should gather qualitative data about previous experiences students had with food and with the project-based learning pedagogical approach. The rubric (Appendix B) should be used to assess student artifacts and analyze how students talk about the projects. The use of the quantitative scale limited the depth of the data collected and analyzed (Nolen, 2020 as cited in Eccles & Wigfield, 2020). Schafbuch (2016) found that the agricultural background students have influences their expectancy-value motivation. Knowledge of previous experiences could help researchers define utility value as intrinsic or extrinsic motivations. Regarding attainment values, further exploration of understanding why it was important for students to participant in the food system STEM project is needed, specifically in understanding if it was the food context, or STEM integration, or all aspects of the project that students valued. Understanding this could help educators make deeper interest connections.

Qualitative data collection focused on cost value could help describe how the project drained the energy of students and why students felt they had to sacrifice a lot of time; investigation could target the length of the project, the concepts covered, costs associated with collaboration, or physical costs. Additional qualitative research should be conducted to investigate what career connections participants made. Students identified value in introduction to potential careers and usefulness to their future careers, but the context could be determined from the quantitative data. It should be further examined if students are making connections to STEM careers or agricultural industry careers or careers within the food system. Qualitative data should be collected through focus group interviews to examine the task values and self-efficacy of high school students. Lastly, future research should look at the other components of the Situated Expectancy Value Theory as they related to the food system STEM project (Eccles & Wigfield, 2020). Researchers should further describe cultural aspects as listed under the cultural milieu and perceptions pieces of the expectancy value model (Eccles & Wigfield, 2020). Researchers should also expand the connection between the goals and general self-schemata of students and their task values, specifically looking at identity.

5.9 Summary

The versatility of food creates many opportunities for students to make relevant connections and motivate students in the classroom. The food system STEM project was interesting, enjoyable, and important to high school urban students. It was also relevant to their future goals and connections to community as well as their self-efficacy. If educators can target student interests and importance through a food complex, the utility value and self-efficacy outcomes will more likely be reflected in effort. Researchers should continue to examine food system STEM projects as a learning experience to help high school students see the relevance in Ag+STEM content and careers.

APPENDIX A: IRB APPROVAL

Date: 11-10-2022

IRB #: 1706019297
Title: Evaluation of the Land-grant Outreach for Community-based Agricultural Learning for Science, Technology, Engineering, and Mathematics (LOCAL STEM) Project
Creation Date: 6-6-2017
End Date:
Status: Approved
Principal Investigator: NEIL KNOBLOCH
Review Board: Exempt Reviewer and Admin Office Actions FY2022
Sponsor: US Department of Agriculture - USDA

Study History

Submission Type Legacy	Review Type Unassigned	Decision
Submission Type Renewal	Review Type Exempt	Decision Exempt

Key Study Contacts

Member NEIL KNOBLOCH	Role Principal Investigator	Contact nknobloc@purdue.edu
Member NEIL KNOBLOCH	Role Primary Contact	Contact nknobloc@purdue.edu

APPENDIX B: FOOD SYSTEM STEM STUDENT PROJECT RUBRIC

This rubric will be used to score the Food System STEM Project Showcase submissions. Please review the rubric before judging the showcase submissions. Use this rubric to evaluate the three showcase submissions. Please fill out the project presentation information in the left corner. For each task description, please check the box that best reflects the project's performance and provide comments on what they did well and how they can improve.

Information about presentation **Project Title:** **School:** **Teachers:** **IDC:** **Scientist:**	**Needs Improvement**	**Good**	**Excellent**	**Comments:**
Problem • Identified and described a problem that can be solved using the IDC				
Connections • Made connections to the local community (who in the community is doing something related to this project–businesses?) • Made connections to potential careers • Made connections to family or out of school activities, connected to life outside of school				

Systems Thinking Does the solution address the four components of the agro-ecosystem: • economic viability • social responsibility • environmental sustainability • production efficiency				
Data • What did students collect as data, what were the variables?				
Solution • **Feasible:** Solution is realistically possible. It's capable of being built within realistic time, financial, resource/material/technology requirements. It's capable of being accessed by the user. • **Viable:** Solution is capable of solving the problem their user faces, without creating more challenges, obstacles, or limitations for the user. • **Desirable:** From the lens of the user, the solution is wished for, wanted, attractive, useful, or necessary to address their needs.				
Innovation • Solution is innovative and original				
Presentation Design • Presentations were professional and clearly stated designs and products • Was easy to tell what was going on in the presentation, logical flow (organization) • Could clearly see what was being highlighted				

APPENDIX C: QUESTIONNAIRE

Food System Motivation Questionnaire

Scale

1 None/not at all

2 Little

3 Somewhat

4 A lot

5 Absolutely

Intrinsic Value

1. Solving a Food System STEM problem is fun to me.
2. I like solving Food System STEM problems.
3. I am interested in solving a Food System STEM problem
4. I enjoy dealing with food systems problems

Personal Utility Value

5. Understanding solving a Food System STEM problem has many benefits in my daily life.
6. Solving a Food System STEM problem comes in handy in everyday life and leisure time.
7. Solving a Food System STEM problem is directly applicable in everyday life.
8. Good grades in solving a Food System STEM problem can be of great value to me later on.
9. Skills from solving a Food System STEM problem will help me in my life.
10. I will often need Food System STEM problem solving skills in my life.
11. Solving a food systems problem will introduce me to potential careers.
12. Solving a food systems problem will be useful in my future career.

Local Context Utility Value

13. Solving a food system problem will make food more available in my community.
14. Solving a food system problem will help make food more affordable in my community.
15. Solving a food system problem will provide healthier food choices in my community.
16. Solving a food systems problem will make my community a more environmentally sustainable place.

17. Solving a food systems problem will make my community a better place to live.

Attainment Value

18. It is important to me to be good at solving a Food System STEM problem.
19. Being good at solving a Food System STEM problem means a lot to me.
20. Performing well in solving a Food System STEM problem is important to me.
21. Good grades in solving a Food System STEM problem are very important to me.

Cost Value

22. Solving a Food System STEM problem is exhausting to me.
23. I often feel completely drained after solving a Food System STEM problem.
24. Dealing with solving a Food System STEM problem drains a lot of my energy.
25. Learning how to solve a Food System STEM problem exhausts me.
26. I have to give up other activities that I like to be successful at solving a Food System STEM problem.
27. I have to give up a lot to do well at solving a Food System STEM problem.
28. I'd have to sacrifice a lot of free time to be good at solving a Food System STEM problem.

Cultural Self-Efficacy

29. I can understand how my culture influences the food choices I make.
30. I can design a solution that would meet the needs of a culturally diverse audience.
31. I can solve the problem using my cultural experiences.
32. I can understand the problem using my cultural experiences.
33. I can understand how food helps me understand my family traditions and culture.

Project Self-Efficacy

34. I can identify a food systems problem that can be solved.
35. I can design solutions to the food systems problem.
36. I can build a solution to the food systems problem.
37. I can apply science, technology, engineering, and mathematics to solve a food systems problem.
38. I can identify the user or stakeholder of the project.
39. I can describe the needs or requirements of the user or stakeholder.
40. I can connect the problem to potential careers.

41. I can collect data using sensors.

Demographics

42. Gender
    a. Male
    b. Female
    c. Non-binary / third gender
    d. Other
    e. Prefer not to say
43. Class
    a. Freshman
    b. Sophomore
    c. Junior
    d. Senior
44. Ethnicity
    a. American Indian or Alaska Native
    b. Asian
    c. Black or African American
    d. Native Hawaiian or Other Pacific Islander
    e. White
    f. Other
45. School
    a. High School A
    b. High School B
    c. High School C

APPENDIX D: FOOD SYSTEM MOTIVATION ITEM FREQUENCIES

Table 13. Frequency of Responses: Intrinsic Value

Items	None / Not at All	A Little	Somewhat	A Lot	Absolutely	*N*
Intrinsic Value						
Solving a Food System STEM problem is fun to me.	7 (10.9%)	16 (25%)	21 (32.8%)	12 (18.8%)	8 (12.5%)	63
I like solving Food System STEM problems.	7 (11.3%)	14 (22.6%)	22 (35.5%)	9 (14.5%)	10 (16.1%)	62
I am interested in solving a Food System STEM problem.	7 (11.1%)	18 (28.6%)	23 (36.5%)	7 (11.1%)	8 (12.7%)	63
I enjoy dealing with food systems problems.	12 (19%)	14 (22.2%)	16 (25.4%)	14 (22.2%)	7 (11.1%)	63

Note. Scale: 1 = None / Not at all, 2 = A little, 3 = Somewhat, 4 = A lot, and 5 = Absolutely.

Table 14. Frequency of Responses: Personal Utility Value Before and Upon Project Completion

Items	None / Not at All	A Little	Somewhat	A Lot	Absolutely	*N*
Personal Utility Value Before the Project						
Understanding solving a Food System STEM problem has many benefits in my daily life.	13 (20.6%)	18 (28.6%)	20 (31.7%)	10 (15.9%)	2 (3.2%)	63
Solving a Food System STEM problem comes in handy in everyday life and leisure time.	13 (21%)	13 (21%)	20 (32.3%)	9 (14.5%)	7 (11.3%)	62
Solving a Food System STEM problem is directly applicable in everyday life.	12 (19.7%)	15 (24.6%)	20 (32.8%)	9 (14.8%)	5 (8.2%)	61
Good grades in solving a Food System STEM problem can be of great value to me later on.	9 (15.3%)	12 (20.3%)	19 (32.2%)	11 (18.6%)	8 (13.6%)	59
Skills from solving a Food System STEM problem will help me in my life.	11 (18.3%)	14 (23.3%)	19 (31.7%)	11 (18.3%)	5 (8.3%)	60
I will often need Food System STEM problem-solving skills in my life.	13 (22%)	12 (20.3%)	19 (32.2%)	9 (15.3%)	6 (10.2%)	59

Table 14 continued

Solving a food system problem will introduce me to potential careers.	8 (14%)	15 (26.3%)	21 (36.8%)	9 (15.8%)	4 (7%)	57
Solving a food system problem will be useful in my future career.	15 (25.9%)	12 (20.7%)	18 (31%)	11 (19%)	2 (3.4%)	58
Personal Utility Value After the Project						
Understanding solving a Food System STEM problem has many benefits in my daily life.	1 (2%)	5 (9.8%)	18 (35.3%)	13 (25.5%)	14 (27.5%)	51
Solving a Food System STEM problem comes in handy in everyday life and leisure time.	4 (8%)	5 (10%)	14 (28%)	15 (30%)	12 (24%)	50
Solving a Food System STEM problem is directly applicable in everyday life.	5 (10.2%)	4 (8.2%)	11 (22.4%)	15 (30.6%)	14 (28.6%)	49
Good grades in solving a Food System STEM problem can be of great value to me later on.	1 (1.9%)	6 (11.3%)	16 (30.2%)	7 (13.2%)	23 (43.4%)	53
Skills from solving a Food System STEM problem will help me in my life.	3 (5.8%)	3 (5.8%)	16 (30.8%)	15 (28.8%)	15 (28.8%)	52
I will often need Food System STEM problem-solving skills in my life.	2 (3.9%)	4 (7.8%)	14 (27.5%)	19 (37.3%)	12 (23.5%)	51
Solving a food system problem will introduce me to potential careers.	5 (9.3%)	5 (9.3%)	14 (25.9%)	11 (20.4%)	19 (35.2%)	54
Solving a food system problem will be useful in my future career.	6 (11.8%)	9 (17.9%)	18 (35.3%)	5 (9.8%)	13 (25.5%)	51

Note. Scale: 1 = None / Not at all, 2 = A little, 3 = Somewhat, 4 = A lot, and 5 = Absolutely.

Table 15. Frequency of Responses: Local Context Utility Value Before and Upon Project Completion

Items	None / Not at All	A Little	Somewhat	A Lot	Absolutely	*N*
Local Context Utility Value Before the Project						
Solving a food system problem will make food more available in my community.	9 (15.5%)	10 (17.2%)	24 (41.4%)	8 (13.8%)	7 (12.1%)	58
Solving a food system problem will make food more affordable in my community.	7 (12.1%)	11 (19%)	24 (41.4%)	9 (15.5%)	7 (12.1%)	58
Solving a food system problem will provide healthier food choices in my community.	7 (12.5%)	12 (21.4%)	19 (33.9%)	11 (19.6%)	7 (12.5%)	56
Solving a food system problem will make my community a more environmentally sustainable place.	7 (12.1%)	14 (24.1%)	20 (34.5%)	10 (17.2%)	7 (12.1%)	58
Solving a food system problem will make my community a better place to live.	6 (10.3%)	10 (17.2%)	24 (41.4%)	13 (22.4%)	5 (8.6%)	58
Local Context Utility Value After the Project						
Solving a food system problem will make food more available in my community.	4 (7.8%)	6 (11.8%)	15 (29.4%)	10 (19.6%)	16 (31.4%)	51
Solving a food system problem will make food more affordable in my community.	3 (5.9%)	8 (15.7%)	12 (23.5%)	12 (23.5%)	16 (31.4%)	51
Solving a food system problem will provide healthier food choices in my community.	3 (5.9%)	4 (7.8%)	17 (33.3%)	10 (19.6%)	17 (33.3%)	51
Solving a food system problem will make my community a more environmentally sustainable place.	2 (3.8%)	7 (13.5%)	15 (28.8%)	9 (17.3%)	19 (36.5%)	52
Solving a food system problem will make my community a better place to live.	2 (3.8%)	7 (13.5%)	14 (26.9%)	13 (25%)	16 (30.8%)	52

Note. Scale: 1 = None / Not at all, 2 = A little, 3 = Somewhat, 4 = A lot, and 5 = Absolutely.

Table 16. Frequency of Responses: Attainment Value

Items	None / Not at All	A Little	Somewhat	A Lot	Absolutely	*N*
Attainment Value						
It is important to me to be good at solving a Food System STEM problem.	6 (10.5%)	8 (14%)	21 (36.8%)	12 (21.1%)	10 (17.5%)	57
Being good at solving a Food System STEM problem means a lot to me.	8 (14%)	9 (15.8%)	18 (31.6%)	15 (26.3%)	7 (12.3%)	57
Performing well in solving a Food System STEM problem is important to me.	5 (8.8%)	9 (15.8%)	20 (35.1%)	14 (24.6%)	9 (15.8%)	57
Good grades in solving a Food System STEM problem are very important to me.	3 (5.3%)	6 (10.5%)	17 (29.8%)	11 (19.3%)	20 (35.1%)	57

Note. Scale: 1 = None / Not at all, 2 = A little, 3 = Somewhat, 4 = A lot, and 5 = Absolutely.

Table 17. Frequency of Responses: Cost Value

Items	None / Not at All	A Little	Somewhat	A Lot	Absolutely	*N*
Cost Value						
Solving a Food System STEM problem is exhausting to me.	12 (20.7%)	20 (34.5%)	16 (27.6%)	6 (10.3%)	4 (6.9%)	58
I often feel completely drained after solving a Food System STEM problem.	13 (22%)	23 (39%)	13 (22%)	4 (6.8%)	6 (10.2%)	59
Dealing with solving a Food System STEM problem drains a lot of my energy.	14 (23.7%)	18 (30.5%)	14 (23.7%)	7 (11.9%)	6 (10.2%)	59
Learning how to solve a Food System STEM problem exhausts me.	14 (24.6%)	14 (24.6%)	15 (26.3%)	10 (17.5%)	4 (7%)	57
I have to give up other activities that I like to be successful at solving a Food System STEM problem.	24 (40.7%)	15 (25.4%)	15 (25.4%)	1 (1.7%)	4 (6.8%)	59
I have to give up a lot to do well at solving a Food System STEM problem.	24 (40.7%)	12 (20.3%)	15 (25.4%)	4 (6.8%)	4 (6.8%)	59
I have to give up a lot to do well at solving a Food System STEM problem.	24 (40.7%)	12 (20.3%)	15 (25.4%)	4 (6.8%)	4 (6.8%)	59
I'd have to sacrifice a lot of free time to be good at solving a Food System STEM problem.	21 (36.2%)	13 (22.4%)	15 (25.9%)	3 (5.2%)	6 (6.5%)	58

Note. Scale: 1 = None / Not at all, 2 = A little, 3 = Somewhat, 4 = A lot, and 5 = Absolutely.

Table 18. Frequency of Responses: Cultural Self-Efficacy Before and Upon Project Completion

Items	None / Not at All	A Little	Somewhat	A Lot	Absolutely	*N*
Cultural Self-efficacy Before Project						
I can understand how my culture influences the food choices I make.	7 (12.1%)	11 (19%)	22 (37.9%)	8 (13.8%)	10 (17.2%)	58
I can design a solution that would meet the needs of a culturally diverse audience.	9 (16.1%)	12 (21.4%)	24 (42.9%)	7 (12.5%)	4 (7.1%)	56
I can solve the problem using my cultural experiences.	10 (18.2%)	9 (16.4%)	19 (34.5%)	10 (18.2%)	7 (12.7%)	55
I can understand the problem using my cultural experiences.	7 (12.3%)	13 (22.8%)	21 (36.8%)	9 (15.8%)	7 (12.3%)	57
I can understand how food helps me understand my family traditions and culture.	9 (16.1%)	6 (10.7%)	18 (32.1%)	18 (32.1%)	5 (8.9%)	56
Cultural Self-efficacy After Project						
I can understand how my culture influences the food choices I make.	3 (5.9%)	7 (13.7%)	12 (23.5%)	15 (29.4%)	14 (27.5%)	51
I can design a solution that would meet the needs of a culturally diverse audience.	2 (3.8%)	6 (11.5%)	24 (46.2%)	8 (15.4%)	12 (23.1%)	52
I can solve the problem using my cultural experiences.	3 (5.8%)	10 (19.2%)	18 (34.6%)	10 (19.2%)	11 (21.2%)	52
I can understand the problem using my cultural experiences.	4 (7.7%)	8 (15.4%)	16 (30.8%)	12 (23.1%)	12 (23.1%)	52
I can understand how food helps me understand my family traditions and culture.	4 (7.4%)	5 (9.3%)	15 (27.8%)	14 (25.9%)	16 (29.6%)	54

Note. Scale: 1 = None / Not at all, 2 = A little, 3 = Somewhat, 4 = A lot, and 5 = Absolutely.

Table 19. Frequency Responses: Project Self-Efficacy Before and Upon Project Completion

Items	None / Not at All	A Little	Somewhat	A Lot	Absolutely	*N*
Project Self-Efficacy Before the Project						
I can identify a food system problem that can be solved.	14 (24.1%)	10 (17.2%)	22 (37.9%)	5 (8.6%)	7 (12.1%)	58
I can design solutions to the food system problem.	12 (20.3%)	11 (18.6%)	20 (33.9%)	10 (16.9%)	6 (10.2%)	59
I can build a solution to the food system problem.	13 (22.8%)	11 (19.3%)	23 (40.4%)	4 (7%)	6 (10.5%)	57
I can apply science, technology, engineering, and mathematics to solve a food system problem.	10 (17.5%)	12 (21.1%)	23 (40.4%)	8 (14%)	4 (7%)	57
I can identify the user or stakeholder of the project.	13 (22.4%)	11 (19%)	18 (31%)	9 (15.5%)	7 (12.1%)	58
I can describe the needs or requirements of the user or stakeholder.	12 (20.7%)	9 (15.5%)	21 (36.2%)	10 (17.2%)	6 (10.3%)	58
I can connect the problem to potential careers.	12 (20.7%)	8 (13.8%)	24 (41.4%)	7 (12.1%)	7 (12.1%)	58
I can use data to make decisions to solve the food system problem.	7 (11.9%)	16 (27.1%)	20 (33.9%)	6 (10.2%)	10 (16.9%)	59
Project Self-Efficacy After the Project						
I can identify a food system problem that can be solved.	4 (7.7%)	2 (3.8%)	22 (42.3%)	10 (19.2%)	14 (26.9%)	52
I can design solutions to the food system problem.	4 (7.5%)	5 (9.4%)	19 (35.8%)	14 (26.4%)	11 (20.8%)	53
I can build a solution to the food system problem.	4 (7.5%)	6 (11.3%)	26 (49.1%)	8 (15.1%)	9 (17%)	53
I can apply science, technology, engineering, and mathematics to solve a food system problem.	4 (7.5%)	3 (5.7%)	18 (34%)	17 (32.1%)	11 (20.8%)	53
I can identify the user or stakeholder of the project.	5 (9.6%)	6 (11.5%)	18 (34.6%)	11 (21.2%)	12 (23.1%)	52
I can describe the needs or requirements of the user or stakeholder.	4 (7.5%)	7 (13.2%)	20 (37.7%)	15 (28.3%)	7 (13.2%)	53
I can connect the problem to potential careers.	4 (7.7%)	7 (13.5%)	16 (30.8%)	13 (25%)	12 (23.1%)	52
I can use data to make decisions to solve the food system problem.	2 (3.8%)	5 (9.65%)	19 (36.5%)	16 (30.8%)	10 (19.2%)	52

Note. Scale: 1 = None / Not at all, 2 = A little, 3 = Somewhat, 4 = A lot, and 5 = Absolutely.

REFERENCES

Alexander, P. A. (2018). The Relevance of Relevance for Learning and Performance. *The Journal of Experimental Education*, *86*(1), 124–135. https://doi.org/10.1080/00220973.2017.1380592

Alharahsheh, H. H., & Pius, A. (2020). A review of key paradigms: Positivism VS interpretivism. *Global Academic Journal of Humanities and Social Sciences*, *2*(3), 39-43.

Akcaoglu, M., Rosenberg, J. M., Ranellucci, J., & Schwarz, C. V. (2018). Outcomes from a self-generated utility value intervention on Fifth and sixth-grade students' value and interest in science. *International Journal of Educational Research*, *87*, 67–77. https://doi.org/10.1016/j.ijer.2017.12.001

Akhtar, I. (2016). Research design. *SSRN Electronic Journal*, 68–84. https://doi.org/10.2139/ssrn.2862445

Anderson II, J. (2013). An exploration of the motivational profile of Secondary Urban Agriculture Students. *Journal of Agricultural Education*, *54*(2), 205–216. https://doi.org/10.5032/jae.2013.02205

Anwar, M. N., Aness, M., Khizar, A., Naseer, M., & Muhammad, G. (2012). Relationship of Creative Thinking with the Academic Achievements of Secondary School Students. *International Interdisciplinary Journal of Education*, *1*(3), 44–47.

Bada, S. O., & Olusegun, S. (2015). Constructivism learning theory: A paradigm for teaching and learning. *Journal of Research & Method in Education*, *5*(6), 66-70.

Ball, C., Huang, K.-T., Cotten, S. R., & Rikard, R. V. (2017). Pressurizing the STEM pipeline: An expectancy-value theory analysis of youths' STEM attitudes. *Journal of Science Education and Technology*, *26*(4), 372–382. https://doi.org/10.1007/s10956-017-9685-1

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191–215. https://doi.org/10.1037/0033-295x.84.2.191

Bandura, A. (1994). Self-efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of human behavior (Vol. 4, pp. 71-81)*. New York: Academic Press. (Reprinted in H. Friedman [Ed.], *Encyclopedia of mental health.* San Diego: Academic Press, 1998).

Bandura, A. (2011). On the functional properties of perceived self-efficacy revisited. *Journal of Management*, *38*(1), 9–44. https://doi.org/10.1177/0149206311410606

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (1996). Multifaceted Impact of Self-Efficacy Beliefs on Academic Functioning. Child Development, 67(3), 1206–1222. https://doi.org/10.2307/1131888

Barton, A. C., Koch, P. D., Contento, I. R., & Hagiwara, S. (2005). From Global Sustainability to Inclusive Education: Understanding urban children's ideas about the food system. *International Journal of Science Education*, *27*(10), 1163–1186. https://doi.org/10.1080/09500690500069467

Beier, M. E., Kim, M. H., Saterbak, A., Leautaud, V., Bishnoi, S., & Gilberto, J. M. (2018). The effect of authentic project-based learning on attitudes and career aspirations in STEM. *Journal of Research in Science Teaching*, *56*(1), 3–23. https://doi.org/10.1002/tea.21465

Bell, S. (2010). Project-Based Learning for the 21st Century: Skills for the future. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *83*(2), 39–43. https://doi.org/10.1080/00098650903505415

Bernard, R. M., Borokhovski, E., Schmid, R. F., Waddington, D. I., & Pickup, D. I. (2019). Twenty-first century adaptive teaching and individualized learning operationalized as specific blends of student-centered instructional events: A systematic review and meta-analysis. *Campbell Systematic Reviews*, *15*(1–2). https://doi.org/10.1002/cl2.1017

Berns, R. G., & Erickson, P. M. (2001). Contextual Teaching and Learning: Preparing Students for the New Economy. The Highlight Zone: Research@ Work No. 5.

Bora, S., & Katz, J. (2019, January 23). *Where does our food come from? Here's why we need to know*. World Economic Forum. Retrieved September 30, 2022, from https://www.weforum.org/agenda/2019/01/where-does-our-food-come-from-heres-why-we-need-to-know/

Briones, E., Tabernero, C., Tramontano, C., Caprara, G. V., & Arenas, A. (2009). Development of a cultural self-efficacy scale for adolescents (CSES-A). *International Journal of Intercultural Relations*, *33*(4), 301–312. https://doi.org/10.1016/j.ijintrel.2009.03.006

Calabrese Barton, A., Koch, P. D., Contento, I. R., & Hagiwara, S. (2005). From Global Sustainability to Inclusive Education: Understanding urban children's ideas about the food system. *International Journal of Science Education*, *27*(10), 1163–1186. https://doi.org/10.1080/09500690500069467

Capraro, R. M., Capraro, M. M., & Morgan, J. R. (2013). STEM project-based learning. *An Integrated Science, Technology, Engineering, and Mathematics (STEM) Approach*, *2*.

Center For Ecoliteracy. (2013). *Nourish Curriculum Guide*. WorldLink.

Charoenmuang, M. (2020). *High School Students' Systems Thinking in the Context of Sustainable Food Systems* (Doctoral dissertation, Purdue University Graduate School).

Chavis, D. M., & Lee, K. (2015). What Is Community Anyway? *Stanford Social Innovation Review*. https://doi.org/10.48558/EJJ2-JJ82

Chou, M. H. (2021). Modeling the relations among task value, strategies, social factors, and English achievement. *The Journal of Educational Research*, *114*(4), 357-366.

Chow, A., Eccles, J. S., & Salmela-Aro, K. (2012). Task value profiles across subjects and aspirations to physical and IT-related sciences in the United States and Finland. *Developmental Psychology*, *48*(6), 1612.

Chumbley, S. B., Haynes, J. C., & Stofer, K. A. (2015). A measure of students' motivation to learn science through agricultural STEM emphasis. *Journal of Agricultural Education*, *56*(4), 107–122. https://doi.org/10.5032/jae.2015.04107

Clark, D. B. (1973). The concept of community: A re-examination. *The Sociological Review*, *21*(3), 397-416.

Cleland, A. B. (2013). *Food Knowledge – what is it and where does it come from; A study of Culinary Management students at William Angliss Institute.* (dissertation).

Cohen, J. (1988). *Statistical Power Analysis for the behavioral sciences*. L. Erlbaum Associates.

Cooper, E. E. (2013). Something to sink their teeth into: Teaching culture through food. *Transformations: The Journal of Inclusive Scholarship and Pedagogy*, *23*(2), 92-105.

Corso, M. J., Bundick, M. J., Quaglia, R. J., & Haywood, D. E. (2013). Where student, teacher, and content meet: Student engagement in the secondary school classroom. *American Secondary Education*, 50-61.

Costello, L. (2018, March 2). Using Agricultural Stereotypes in the Media to Prepare Students for Careers in Agriculture. *The Agricultural Education Magazine*, *90*(4), 10–12.

Desimone, L. M. (2013). Teacher and administrator responses to standards-based reform. *Teachers College Record: The Voice of Scholarship in Education*, *115*(8), 1–53. https://doi.org/10.1177/016146811311500805

DeVito, M. (2016). Facotrs Influencing Student Engagement. Unpublished Certificate of Advanced Study Thesis, Sacred Hear University, Fairfield, CT. Retrieved from http://digitalcommons.sacredheart.edu/edl/11

Devlin, A. S. (2021). *The research experience planning, conducting, and reporting research*. SAGE Publications, Inc.

Earnshaw, V. A., & Karpyn, A. (2020). Understanding stigma and food inequity: A conceptual framework to inform research, intervention, and policy. *Translational Behavioral Medicine*, *10*(6), 1350–1357. https://doi.org/10.1093/tbm/ibaa087

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, *53*(1), 109–132. https://doi.org/10.1146/annurev.psych.53.100901.135153

Eccles, J. S., & Wigfield, A. (2020, April). From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation. *Contemporary Educational Psychology*, *61*, 101859. https://doi.org/10.1016/j.cedpsych.2020.101859

Enriquez, J. P., & Archila-Godinez, J. C. (2021). Social and cultural influences on food choices: A Review. *Critical Reviews in Food Science and Nutrition*, *62*(13), 3698–3704. https://doi.org/10.1080/10408398.2020.1870434

Emery, N., Maher, J. M., & Ebert-May, D. (2021). Environmental influences and individual characteristics that affect learner-centered teaching practices. *PLOS ONE*, *16*(4), e0250760. https://doi.org/10.1371/journal.pone.0250760

Felder, R. M., & Brent, R. (2007). Cooperative learning. Active learning: Models from the analytical sciences, 970, 34-53.

Firman, H., Rustaman, N. Y., & Suwarma, I. R. (2015). Development Technology and engineering literacy through STEM-based education. *Proceedings of the 2015 International Conference on Innovation in Engineering and Vocational Education*, 209–212. https://doi.org/10.2991/icieve-15.2016.45

Ford, V. B., & Roby, D. E. (2013). Why Do High School Students Lack Motivation in the Classroom?. *Global Education Journal*, *2013*(2).

Forghani-Arani, N., Cerna, L., & Bannon, M. (2019, March 14). *The lives of teachers in diverse classrooms. Home Page. Retrieved 2023, from https://doi.org/10.1787/8c26fee5-en*

Fredricks, J. A., Hofkens, T., Wang, M.-T., Mortenson, E., & Scott, P. (2018). Supporting girls' and boys' engagement in math and science learning: A mixed methods study. *Journal of Research in Science Teaching*, *55*(2), 271–298. https://doi.org/10.1002/tea.21419

Fredricks, J. A., Reschly, A. L., & Christenson, S. L. (2019). Interventions for student engagement: Overview and state of the field. *Handbook of Student Engagement Interventions*, 1–11. https://doi.org/10.1016/b978-0-12-813413-9.00001-2

Fresco, L. O., & Kroonenberg, S. B. (1992). Time and spatial scales in ecological sustainability. *Land Use Policy*, *9*(3), 155–168. https://doi.org/10.1016/0264-8377(92)90040-4

Friedel, C., & Anderson, J. (2017). An Exploration of Relationships between Teaching Practices in Secondary Agricultural Education Programs and Student Engagement. *Journal of Agricultural Education*, *58*(2), 180–197. https://doi.org/10.5032/jae.2017.02180

Frymier, A. B., & Shulman, G. M. (1995). "What's in it for me?": Increasing content relevance to enhance students' motivation. *Communication Education*, *44*(1), 40–50. https://doi.org/10.1080/03634529509378996

Gaspard, H., Dicke, A. L., Flunger, B., Schreier, B., Häfner, I., Trautwein, U., & Nagengast, B. (2015). More value through greater differentiation: Gender differences in value beliefs about math. Journal of Educational Psychology, 107(3), 663–677. https://doi.org/10.1037/edu0000003

Gero, A., & Zach, E. (2014). High school programme in electro-optics: A case study on interdisciplinary learning and systems thinking. *International Journal of Engineering Education*, *30*(5), 1190-1199.

Gladstone, J. R., Wigfield, A., & Eccles, J. S. (2022). Situated expectancy-value theory, dimensions of engagement, and academic outcomes. *Handbook of Research on Student Engagement*, 57–76. https://doi.org/10.1007/978-3-031-07853-8_3

Gray, R. (2018). Assessing the Differential Impact of Two Sources of Utility Value Information on Student Utility Value and Interest. ProQuest Dissertations Publishing.

Green, P. (2015). How to motivate students. *AAPT Studies in Pedagogy*, *1*, 47–60. https://doi.org/10.5840/aaptstudies20159184

Harmon, A. H., & Maretzki, A. N. (2006). Assessing food system attitudes among youth: Development and evaluation of attitude measures. *Journal of Nutrition Education and Behavior*, *38*(2), 91–95. https://doi.org/10.1016/j.jneb.2005.11.029

Hattie, J. A., & Donoghue, G. M. (2016). Learning strategies: A synthesis and conceptual model. *Npj Science of Learning*, *1*(1). https://doi.org/10.1038/npjscilearn.2016.13

Herrington, J., Reeves, T. C., & Oliver, R. (2014). *Authentic learning environments* (pp. 401-412). Springer New York.

Hildebrand, D. (2018). John Dewey. *Stanford Encyclopedia of Philosophy*. https://plato.stanford.edu/archives/win2021/entries/dewey/

Hilimire, K., Gillon, S., McLaughlin, B. C., Dowd-Uribe, B., & Monsen, K. L. (2014). Food for thought: Developing curricula for Sustainable Food Systems Education Programs. *Agroecology and Sustainable Food Systems*, *38*(6), 722–743. https://doi.org/10.1080/21683565.2014.881456

Hilimire, K. (2016). Theory and Practice of an Interdisciplinary Food Systems Curriculum 1. *NACTA Journal, 60*(2), 227-233. https://www.proquest.com/scholarly-journals/theory-practice-interdisciplinary-food-systems/docview/1803766005/se-2

Hilton, M. (2015). Preparing Students for Life and Work. Issues in Science and Technology, 31(4), 63–66. https://www.proquest.com/scholarly-journals/preparing-students-life-work/docview/1744812376/se-2

Hopkins, W. G. (2002). *A Scale of Magnitudes for Effect Statistics*. New view of statistics: Effect magnitudes. Retrieved from https://www.sportsci.org/resource/stats/effectmag.html

Hulleman, C. S., Durik, A. M., Schweigert, S. A., & Harackiewicz, J. M. (2008). Task values, achievement goals, and interest: An integrative analysis. *Journal of Educational Psychology*, *100*(2), 398–416. https://doi.org/10.1037/0022-0663.100.2.398

Indiana Department of Education. (n.d.). *School Profile Look Up*. Inview.doe.in.gov. Retrieved from https://inview.doe.in.gov/

Indiana Department of Education. (2021). Inview.doe.in.gov. Retrieved November 15, 2022, from https://inview.doe.in.gov/

Indiana Department of Education STEM Council. (2018). *Indiana STEM Six Year Strategic Plan.* Retrieved from https://cdn.ymaws.com/www.acecindiana.org/resource/resmgr/workforce/indiana_stem_six-year_strate.pdf

Interagency working group on convergence federal coordination in STEM education subcommittee committee on STEM education. (2022, November). Convergence education: a guide to transdisciplinary STEM learning and teaching. The White House. Retrieved from https://www.whitehouse.gov/ostp/news-updates/reports-and-documents/

Jia, Y., Zhou, B., & Zheng, X. (2021). A curriculum integrating STEAM and Maker Education promotes pupils' learning motivation, self-efficacy, and interdisciplinary knowledge acquisition. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.725525

Jones, M. G., Chesnutt, K., Ennes, M., Mulvey, K. L., & Cayton, E. (2021). Understanding science career aspirations: Factors predicting future science task value. *Journal of Research in Science Teaching*, *58*(7), 937–955. https://doi.org/10.1002/tea.21687

Juuti, K., Lavonen, J., Salonen, V., Salmela-Aro, K., Schneider, B., & Krajcik, J. (2021). A teacher–researcher partnership for professional learning: Co-designing project-based learning units to increase student engagement in science classes. *Journal of Science Teacher Education*, *32*(6), 625–641. https://doi.org/10.1080/1046560x.2021.1872207

Kelley, T. R., & Knowles, J. G. (2016). A Conceptual Framework for Integrated STEM Education. *International Journal of STEM Education*, *3*(1). https://doi.org/10.1186/s40594-016-0046-z

Knobloch, N. (2021). An Introduction: Teaching and Learning in Urban Agricultural Community Contexts. In: DeCoito, I., Patchen, A., Knobloch, N., Esters, L. (eds) Teaching and Learning in Urban Agricultural Community Contexts. Urban Agriculture. Springer, Cham. https://doi.org/10.1007/978-3-030-72888-5_1

Knobloch, N. A., [Learner-Centered Teaching]. LCT Module 4 - Learning Experiences Using Active Learning (2021a, October 31). [Video]. YouTube. https://www.youtube.com/watch?v=WqRRNtwrRLg.

Knobloch, N. A., [Learner-Centered Teaching]. LCT Module 5 - Learning Experiences Using Inquiry Learning (2021b, October 31). [Video]. YouTube. https://www.youtube.com/watch?v=qWbxP6af0KE

Knobloch, N. A., [Learner-Centered Teaching]. LCT Module 6 – Learning Experiences Using Contextual Learning (2021c, October 31). [Video]. YouTube. https://www.youtube.com/watch?v=ml29z1miOGA

Knobloch, N. A., [Learner-Centered Teaching]. LCT Module 8 – Introduction of Culturally Responsive Teaching (2021d, October 31). [Video]. YouTube. https://youtu.be/OgvNNVrj1GU

Knobloch, N. A., [Learner-Centered Teaching]. LCT Module 9 – Diverse Student-Centered Teaching Strategies (2021e, October 31). [Video]. YouTube. https://www.youtube.com/watch?v=o9fMg76XOkE

Knobloch, N., Ball, A., & Allen, C. (2007). The benefits of teaching and learning about agriculture in elementary and junior high schools. *Journal of Agricultural Education*, *48*(3), 25–36. https://doi.org/10.5032/jae.2007.03025

Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving Schools*, *19*(3), 267–277. https://doi.org/10.1177/1365480216659733

Kornegay, R. D. (2021). *Exploring Diverse Rural Elementary Students' Interests And Concerns Of The Food System After Participating In A Virtual Agri+ STEM Experience* (Doctoral dissertation, Purdue University).

Kovar, K., & Ball, A. (2013). Two decades of Agricultural Literacy Research: A synthesis of the literature. *Journal of Agricultural Education*, *54*(1), 167–178. https://doi.org/10.5032/jae.2013.01167

Leaper, C. (2011). More similarities than differences in contemporary theories of social development? *Advances in Child Development and Behavior*, 337–378. https://doi.org/10.1016/b978-0-12-386491-8.00009-8

Lee, T. D., Gail Jones, M., & Chesnutt, K. (2017). Teaching systems thinking in the context of the water cycle. *Research in Science Education*, *49*(1), 137–172. https://doi.org/10.1007/s11165-017-9613-7

Learner-centered, future-focused education - Indiana. Indiana Department of Education. (2021). Retrieved 2023, from https://www.in.gov/doe/about/

Legault, L., Green-Demers, I., & Pelletier, L. (2006). Why Do High School Students Lack Motivation in the Classroom? Toward an Understanding of Academic Amotivation and the Role of Social Support. Journal of Educational Psychology, 98(3), 567–582. https://doi.org/10.1037/0022-0663.98.3.567

Little, D. (2019). Positivism. In P. Atkinson, S. Delamont, A. Cernat, J.W. Sakshaug, & R.A. Williams (Eds.), *SAGE Research Methods Foundations.* https://dx.doi.org/10.4135/9781526421036837552

Lund Dean, K., & Jolly, J. P. (2012). Student identity, disengagement, and learning. *Academy of Management Learning & Education*, *11*(2), 228–243. https://doi.org/10.5465/amle.2009.0081

Mat Roni, S., Merga, M. K., & Morris, J. E. (2020). Conducting Quantitative Research in Education (1st ed. 2020.). Springer Singapore. https://doi.org/10.1007/978-981-13-9132-3

Meek, D., & Tarlau, R. (2015). Critical Food Systems Education (CFSE): Educating for food sovereignty. *Agroecology and Sustainable Food Systems*, *40*(3), 237–260. https://doi.org/10.1080/21683565.2015.1130764

Michel, N., Cater, J. J., & Varela, O. (2009). Active versus passive teaching styles: An empirical study of student learning outcomes. *Human Resource Development Quarterly*, *20*(4), 397–418. https://doi.org/10.1002/hrdq.20025

Milner, H. R. (2010). Culturally relevant pedagogy in a diverse urban classroom. *The Urban Review*, *43*(1), 66–89. https://doi.org/10.1007/s11256-009-0143-0

Moore, T. J., Johnston, A. C., & Glancy, A. W. (2020). STEM integration: A synthesis of conceptual frameworks and definitions. In *Handbook of research on STEM education* (pp. 3-16). Routledge.

Moore, T. J., & Smith, K. A. (2014). Advancing the State of the Art of STEM Integration. *Journal of STEM Education*, *15*(1), 5–10.

Nagarajan, S., & Overton, T. (2019). Promoting Systems Thinking Using Project- and Problem-Based Learning. *Journal of Chemical Education*, *96(12)*, 2901–2909. https://doi.org/10.1021/acs.jchemed.9b00358

Nanayakkara, J., Margerison, C., & Worsley, A. (2017). Importance of food literacy education for Senior Secondary School Students: Food System Professionals' opinions. *International Journal of Health Promotion and Education*, *55*(5-6), 284–295. https://doi.org/10.1080/14635240.2017.1372695

National Association of State Administrators of Family and Consumer Sciences (NASAFACS). (2008). *National Standards for Family and Consumer Sciences Education*. Retrieved from https://opi.mt.gov/Portals/182/Page%20Files/Career%20%26%20Technical%20Education/Docs/FCS/15FCS_NationalStandards.pdf

National Center for Education Statistics, U.S. Department of Education. (n.d.). *School Directory Information*. Institution of Education Sciences National Center for Education Statistics (NCES). Retrieved 2023, from https://nces.ed.gov/ccd/schoolsearch/school_detail.asp?Search=1&Zip=46225&ID=180018302632

National Science & Technology Council. (2018). *Charting a Course for Success: America's Strategy for STEM Education. A Report by the Committee on STEM Education of the National Science & Technology Council*. Executive Office of the President. https://files.eric.ed.gov/fulltext/ED590474.pdf

Nelson, B., & Thies, S. (2022) Student Incubated Design Challenge Presentation Evaluation [Rubric].

Nikitina, S. (2006). Three strategies for interdisciplinary teaching: Contextualizing, conceptualizing, and problem-centring. *Journal of Curriculum Studies*, *38*(3), 251–271. https://doi.org/10.1080/00220270500422632

Oettingen, G. (1995). Cross-cultural perspectives on self-efficacy. *Self-efficacy in changing societies*, 149-176. https://doi.org/10.1017/CBO9780511527692.007

Ojose, B. (2011). Mathematics literacy: Are we able to put the mathematics we learn into everyday use. *Journal of mathematics education*, *4*(1), 89-100.

Ortiz-Revilla, J., Adúriz-Bravo, A., & Greca, I. M. (2020). A framework for epistemological discussion on integrated STEM education. *Science & Education*, *29*(4), 857–880. https://doi.org/10.1007/s11191-020-00131-9

Østerlie, O., Løhre, A., & Haugan, G. (2018). The Expectancy-Value Questionnaire in Physical Education: A Validation Study Among Norwegian Adolescents. *Scandinavian Journal of Educational Research*, *63*(6), 869–883. https://doi.org/10.1080/00313831.2018.1453867

Overall (all ages) hunger & poverty in Indiana: Map the meal gap. Feeding America. (2022). Retrieved 2023, from https://map.feedingamerica.org/county/2020/overall/indiana

Park, Y. S., Konge, L., & Artino, A. R. (2020). The positivism paradigm of research. *Academic Medicine*, *95*(5), 690–694. https://doi.org/10.1097/acm.0000000000003093

Perin, D. (2011). Facilitating student learning through contextualization: A review of evidence. *Community College Review*, *39*(3), 268-295.

Pope, H., de Frece, A., Wells, R., Borrelli, R., Ajates, R., Arnall, A., Blake, L. J., Dadios, N., Hasnain, S., Ingram, J., Reed, K., Sykes, R., Whatford, L., White, R., Collier, R., & Häsler, B. (2021). Developing a functional food systems literacy for Interdisciplinary Dynamic Learning Networks. *Frontiers in Sustainable Food Systems*, *5*. https://doi.org/10.3389/fsufs.2021.747627

Posner, D. (2004). What's wrong with teaching to the test? *Phi Delta Kappan*, *85*(10), 749–751. https://doi.org/10.1177/003172170408501009

Pratt, C. (2000). Measuring program outcomes: Using retrospective pretest methodology. *The American Journal of Evaluation*, *21*(3), 341–349. https://doi.org/10.1016/s1098-2140(00)00089-8

President's Council of Advisors on Science and Technology. (2010). *Prepare and inspire: K-12 education in science, technology, engineering, and math (STEM) for America's future.* Washington, DC: Executive Office of the President.

Privitera, G. (2018). *Statistics for the Behavioral Sciences*. Sage.

Rehman, A. A., & Alharthi, K. (2016). An introduction to research paradigms. *International Journal of Educational Investigations*, *3*(8), 51-59.

Reschly, A. L., & Christenson, S. L. (2022). Jingle-Jangle revisited: History and further evolution of the student engagement construct. *Handbook of Research on Student Engagement*, 3–24. https://doi.org/10.1007/978-3-031-07853-8_1

Roberts, P., Priest, H., & Traynor, M. (2006). Reliability and validity in research. *Nursing Standard*, *20*(44), 41–45.

Rozek, C. S., Svoboda, R. C., Harackiewicz, J. M., Hulleman, C. S., & Hyde, J. S. (2017). Utility-value intervention with parents increases students' STEM preparation and career pursuit. *Proceedings of the National Academy of Sciences*, *114*(5), 909-914.

Russell, C., Robinson, J. S., & Kelsey, K. (2009). Motivating Agriculture Students to Participate in Career Development Events. Career and Technical Education Research, 34(2), 103–118. https://doi.org/10.5328/CTER34.2.103

Schafbuch, M. (2016). Expectancy-Value in The Enrollment Factor of Agricultural Education Youth. [Master's thesis, University of Kentucky]. University of Kentucky Community and Leadership Development. https://doi.org/10.13023/ETD.2016.518

Scherer, A. K. (2016). *High school students' motivations and views of agriculture and agricultural careers upon completion of a pre-college program* (dissertation). ProQuest Dissertations & Theses, Ann Arbor.

Schnitzler, K., Holzberger, D., & Seidel, T. (2020). All better than being disengaged: Student engagement patterns and their relations to academic self-concept and achievement. *European Journal of Psychology of Education*, *36*(3), 627–652. https://doi.org/10.1007/s10212-020-00500-6

Schussler, D. L. (2009). Beyond content: How teachers manage classrooms to facilitate intellectual engagement for disengaged students. *Theory Into Practice*, *48*(2), 114–121. https://doi.org/10.1080/00405840902776376

Search agriculture companies in Indiana. zoominfo. (n.d.). Retrieved 2023, from https://www.zoominfo.com/companies-search/location-usa--indiana-industry-agriculture

Search for Public Schools. National Center for Education Statistics (NCES) Home Page, a part of the U.S. Department of Education. (2021). Retrieved November 15, 2022, from https://nces.ed.gov/ccd/schoolsearch/school_detail.asp?Search=1&DistrictID=2100360&ID=210036000060

Semilarski, H., Soobard, R., & Rannikmäe, M. (2021). Promoting students' perceived self-efficacy towards 21st century skills through everyday life-related scenarios. *Education Sciences*, *11*(10), 570. https://doi.org/10.3390/educsci11100570

Serdyukov, P. (2017). Innovation in education: What works, what doesn't, and what to do about it? *Journal of Research in Innovative Teaching & Learning*, *10*(1), 4–33. https://doi.org/10.1108/jrit-10-2016-0007

Skaalvik, E. M., Federici, R. A., Wigfield, A., & Tangen, T. N. (2017). Students' perceptions of mathematics classroom goal structures: Implications for perceived task values and study behavior. *Social Psychology of Education*, *20*(3), 543–563. https://doi.org/10.1007/s11218-017-9382-1

Smith, S., Null, D., & Zimmerman, K. (2019). Understanding teacher perceptions of school gardens and food access in rural food deserts. *NACTA Journal*, *63*(2), 208-214.

Smith, E., Park, T., & Sutton, M. (2009). High school students' perceptions and knowledge about agriculture based upon location of the high school. *NACTA Journal*, 17-23.

Snyder, S. (2009). Ethnographies of Taste: Cooking, Cuisine, and Cultural Literacy. *Journal of Agricultural and Environmental Ethics*, *22*(3), 273–283. https://doi.org/10.1007/s10806-009-9149-6

Solley, B. A. (2007). On standardized testing: An ACEI position paper. *Childhood Education*, *84*(1), 31–37. https://doi.org/10.1080/00094056.2007.10522967

Spencer, M. B., Offidani-Bertrand, C., Harris, K., & Velez, G. (2020). Examining links between culture, identity, and learning. *Handbook of the Cultural Foundations of Learning*, 44–61. https://doi.org/10.4324/9780203774977-4

STATS Indiana, The Indiana Department of Workforce Development. (2018). *Hoosiers by the numbers*. County Highlights: Hoosiers by the Numbers. Retrieved 2023, from https://www.hoosierdata.in.gov/highlights/default.asp

Stofer, K. A., & Rios, C. (2018). Contextualizing Science Learning through Agricultural Free-Choice Learning Opportunities in Your Backyard. *Science Educator*, *26*(2), 114-121.

Stratton, S. (2019). Quasi-Experimental Design (Pre-Test and Post-Test Studies) in Prehospital and Disaster Research. *Prehospital and Disaster Medicine, 34*(6), 573-574. doi:10.1017/S1049023X19005053

Stehle, S. M., & Peters-Burton, E. E. (2019). Developing student 21st Century skills in selected exemplary inclusive STEM High Schools. *International Journal of STEM Education*, *6*(1). https://doi.org/10.1186/s40594-019-0192-1

The National Council for Agricultural Education. (2015). *Agriculture, Food and Natural Resources (AFNR) Career Cluster*.

Thibaut, L., Ceuppens, S., De Loof, H., De Meester, J., Goovaerts, L., Struyf, A., Boeve-de Pauw, J., Dehaene, W., Deprez, J., De Cock, M., Hellinckx, L., Knipprath, H., Langie, G., Struyven, K., Van de Velde, D., Van Petegem, P., & Depaepe, F. (2018). Integrated STEM Education: A systematic review of instructional practices in Secondary Education. *European Journal of STEM Education*, *3*(1). https://doi.org/10.20897/ejsteme/85525

Thiel, B., & Marx, A. (2019). The influence of Agriscience Research Saes on perceived self-efficacy of 21st century skill attainment. *Journal of Agricultural Education*, *60*(01). https://doi.org/10.5032/jae.2019.01080

Tunjungsari, H., & Takwin, B. (2021). Understanding critical thinking practice in everyday life through stages of critical thinking skills and disposition. *Mind, Brain, and Education*, *15*(3), 225–231. https://doi.org/10.1111/mbe.12279

Turiman, P., Omar, J., Daud, A. M., & Osman, K. (2012). Fostering the 21st century skills through scientific literacy and science process skills. *Procedia - Social and Behavioral Sciences*, *59*, 110–116. https://doi.org/10.1016/j.sbspro.2012.09.253

Tze, V. M., Daniels, L. M., & Klassen, R. M. (2015). Evaluating the relationship between boredom and academic outcomes: A meta-analysis. *Educational Psychology Review*, *28*(1), 119–144. https://doi.org/10.1007/s10648-015-9301-y

United States Department of Education. (n.d.). *Science, Technology, engineering, and math, including Computer Science*. Science, Technology, Engineering, and Math, including Computer Science. Retrieved December 4, 2022, from https://www.ed.gov/stem

Urban Agriculture. Natural Resources Conservation Service USDA. (2023, March 16). Retrieved from https://www.nrcs.usda.gov/getting-assistance/other-topics/urban-agriculture

U.S. Census Bureau. (2022). *U.S. Census Bureau quickfacts: United States*. U.S. Census Bureau. Retrieved from https://www.census.gov/quickfacts/fact/table/indianapoliscitybalanceindiana,southbendcityindiana/PST045222,PST045221

USDA. (2020). *Rural-urban commuting area codes*. USDA ERS - Rural-Urban Commuting Area Codes. Retrieved 2023, from https://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes/

Vasquez, J. A., Sneider, C., & Comer, M. (2013). *STEM Lesson Essentials, Grades 3-8: Integrating Science, Technology, Engineering, and Mathematics*. Heinemann.

Wang, H. H., & Knobloch, N. A. (n.d.). Projects: Industry-Driven Integrated STEM and Systems Approach to Innovative Incubation (IN-VISION) Project (2020 – 2024). Purdue University - College of Agriculture. Retrieved September 14, 2022, from https://ag.purdue.edu/department/asec/boilersteam/projects.html

Wang, H. H., & Knobloch, N. (2018). Levels of STEM integration through agriculture, food, and Natural Resources. *Journal of Agricultural Education*, *59*(3), 258–277. https://doi.org/10.5032/jae.2018.03258

Wang, H. H., & Knobloch, N. A. (2022). An action research study of levels of STEM integration through agriculture, food and natural resources. *Journal of Pedagogical Research*, 6(2), 4-25. https://dx.doi.org/10.33902/JPR.202113513

Wang, H. H., & Knobloch, N. A. (2022). Preservice educators' interpretations and pedagogical benefits of a STEM integration through agriculture, food and natural resources rubric. Journal of Pedagogical Research, 6(2). https://doi.org/10.33902/jpr.202213513

Wang, H. H., & Knobloch, N. A. (2023). K-12 teachers' beliefs and practices in STEM integration. In International Encyclopedia of Education (Fourth Edition, pp. 251–261). Elsevier Ltd. https://doi.org/10.1016/B978-0-12-818630-5.13070-2

Wang, H. H., Nelson, B. J., Knobloch, N. A. (2021). Industry Driven Integrated STEM and Systems Approach to Innovative Incubation. Presentation at the National Learner Centered Teaching Conference, Columbus, OH.

Webb, P. K. (1980). Piaget: Implications for teaching. *Theory Into Practice*, *19*(2), 93–97. https://doi.org/10.1080/00405848009542880

Weimer, M. (2003). Focus on learning, transform teaching. *Change: The Magazine of Higher Learning*, *35*(5), 48–54. https://doi.org/10.1080/00091380309604119

Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation. *Contemporary Educational Psychology*, *25*(1), 68–81. https://doi.org/10.1006/ceps.1999.1015

Wigfield, A., & Eccles, J. S. (2020). 35 years of research on students' subjective task values and motivation: A look back and a look forward. *Advances in Motivation Science*, 161–198. https://doi.org/10.1016/bs.adms.2019.05.002

Willems, P. P., & Gonzalez-DeHass, A. R. (2012). School-Community Partnerships: Using Authentic Contexts to Academically Motivate Students. *School Community Journal*, *22*(2), 9-30.

Williams, M. K. (2017). John Dewey in the 21st century. *Journal of Inquiry and Action in Education*, *9*(1), 7.

Wiskerke, J. S. C. (2015). Urban food systems. In *Cities and Agriculture Developing Resilient Urban Food Systems* (pp. 1–25). essay, Routledge.

Wolsey, T. D., & Lapp, D. (2014). School gardens: Situating students within a global context. *Journal of education*, *194*(3), 53-60.

Yildirim, S., & Tezci, E. (2016). Teachers' attitudes, beliefs and self-efficacy about multicultural education: A scale development. *Universal Journal of Educational Research*, *4*(12A), 196–204. https://doi.org/10.13189/ujer.2016.041325

York, S., Lavi, R., Dori, Y. J., & Orgill, M. K. (2019). Applications of systems thinking in STEM education. *Journal of Chemical Education*, *96*(12), 2742–2751. https://doi.org/10.1021/acs.jchemed.9b00261

VITAE

A Montana native, Sarah Thies grew up in a small agricultural community. Through 4-H experiences, she found her passion for teaching and sharing with others about the agricultural industry. She earned a Bachelor of Science in Agricultural Education Broadfield Teaching with a minor in Family and Consumer Sciences Teaching from Montana State University Bozeman.

Under the mentorship of Dr. Neil Knobloch, Sarah gained experience in learner-centered teaching, integrated STEM, systems thinking, instructional design, website management, and award programs. Sarah co-developed an "Apple Preservation and Packaging Unit" for 4^{th} – 6^{th} graders that engaged them in the science, technology, and engineering processes that get sliced apples and other apple products from the orchard to their table. Sarah also developed a needs assessment for sheep producers in the U.S. Based on the results, she developed a public Sheep Marketing educational website for sheep producers and educators. Upon graduation, Sarah aspires to educate youth about the agricultural industry and encourage students to pursue careers in agriculture.

PUBLICATIONS

PEER-REVIEWED CONFERENCE ABSTRACTS AND PAPERS

1. Thies, S. L. J., Knobloch, N. A., Wilson, C. A., & Kornegay, R. D. (2022, May). Faculty and Staff Award Recipients' Perceived Value of a PK-12 Awards Program. Poster presentation at the American Association of Agricultural Education, Oklahoma City, OK.
2. Thies, S. L. J., Knobloch, N. A., Wilson, C. A., & Kornegay, R. D. (2022). Faculty and Staff Award Recipients' Perceived Value of a PK-12 Awards Program. Poster presentation at the North American Colleges and Teachers of Agriculture Conference, Wooster, OH.
3. Thies, S. L. J., Knobloch, N. A., Wang, H. H., Nelson, B. J. (2022, October). High School Student Perceptions of a Food System Integrated STEM Project. Poster presentation at the North Central American Association of Agricultural Education Conference, Columbia, MO
4. Thies, S. L. J., Blackburn, J. (2022, October). Teaching Apple Preservation and Packaging with Integrated STEM through AFNR. Poster presentation at the North Central American Association of Agricultural Education Conference, Columbia, MO