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A Pedagogical Framework for the Design and Utilization of Place-Based Experiential Learning Curriculum on a Campus Farm

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Abstract: Campus agriculture projects are increasingly being recognized as spaces impactful to student engagement and learning through curricular and co-curricular programming; however, most campus farm activities are limited to agriculture or sustainability programs and/or co-curricular student clubs. Thus, campus farms are largely underutilized in the undergraduate curriculum, marking a need to explore the efficacy and impact of engaging a diverse array of disciplinary courses in the rich social, environmental, and civic context of local sustainable agriculture. The Farm Hub program presented here incentivizes instructors to refocus a portion of existing course content around the topic of local, sustainable agriculture, and reduces barriers to using a campus farm as a situated learning context for curricula. A pedagogical framework founded in place-based experiential learning (PBEL) theory was developed to guide instructors in the development and implementation of 4–6-week inquiry-based PBEL modules embedded in existing courses. The framework was converted into a research protocol to quantify program implementation fidelity and PBEL best practice adherence for the proposed lesson plans (intended) and their implementation (applied). The framework enables the development of a cohesive cross-curricular program so that the impact of implementation fidelity and best practice adherence to student learning outcomes in scientific literacy, place attachment and meaning, and civic mindedness can be assessed and the results utilized to develop a formal farm-situated PBEL pedagogical taxonomy. This framework can be applied to PBEL curriculum in natural spaces beyond campus farms.

Keywords: *educational framework, sustainable agriculture, curriculum, interdisciplinary, pedagogy, place-based, undergraduate, civic mindedness*

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Agriculture projects on college campuses have increased 13-fold since 1992—tripling between 2011 and 2015 to involve over 300 campuses (LaCharite, 2016). While land grant colleges have a long history of agriculture programs, most of the growth in campus agriculture projects has occurred outside of land grant colleges as a result of increased student interest in sustainability, a recognition of the value of experiential, community-based learning, and the interdisciplinary potential of these spaces (LaCharite, 2016). Despite their impact to student learning and civic engagement, educational activities in campus farm spaces are primarily focused on sustainable agriculture and food systems courses and/or often lack structured curricular programs with a common learning framework, leaving untapped potential for campus farms to serve as a resource for a more diverse array of disciplinary learning.

Place-based experiential learning (PBEL) has been shown in the K12 realm as an effective pedagogy to enhance student content knowledge, engagement, critical thinking skills, and civic mindedness, particularly when placed within school gardens or campus farms (Sobel, 2004). Other than research on the impact of campus farms as a resource for agriculture-based curriculum, sustainability initiatives, and co-curricular student leadership (LaCharite, 2016), there has been no research on the impact of farm-based PBEL in non-agricultural fields of study at the collegiate level. Yet, campus agriculture projects, especially set within an urban environment, present innovative opportunities to research and teach multidisciplinary perspectives of socio-ecological, cultural, and political aspects of the environment. However, the challenge of linking local-scale problems to global phenomena combined with a lack of instructor training in PBEL pedagogical methods and locality-specific content creates major barriers to effectively implement this learning framework in the context of campus farms or other campus and community spaces (Gruenewald, 2003).

Educational taxonomies that tie cognitive learning attributes to instructor practices are useful instruments to guide instructors in the development and implementation of learning pedagogies, particularly for those that can be difficult to effectively implement such as PBEL. Before a formal taxonomy can be created, a pedagogical framework needs to be developed and tested for efficacy to specific learning outcomes. Using existing literature and preliminary trials in biology, ecology, environmental studies, and chemistry courses, a PBEL pedagogical framework is presented here to guide instructors in the development and implementation of campus farm-situated sustainable agriculture research modules. This framework could then be used to quantify *intended* and *applied* fidelity to the PBEL pedagogical framework before relating such quantitative fidelity scores back to student learning outcomes—associated with environmental science literacy, scientific reasoning, place attachment and meaning, and civic mindedness—ultimately leading to the development of a PBEL taxonomy for natural campus and community spaces.

Development of the Farm Hub Program and PBEL Pedagogical Framework

The Farm Hub Program

In 2016, the Center for Urban Ecology and Sustainability (CUES) at Butler University developed a farm-situated PBEL curricular program (hereafter referred to the Farm Hub program) that uses a campus farm as a hub for cross-disciplinary education and research. Farm

Hub course modules have been or are currently being implemented in existing courses in four different disciplines (biology, ecology, environmental studies, chemistry) with intentions to extend module reach into five additional disciplines (health sciences, communications, business, primary education, and religion) in the near future. The impact of this expanded use of a campus farm to student learning outcomes, faculty collaboration, and institutional support for sustainability is currently being assessed. The long-term vision for the Farm Hub program is to increase connections between the campus farm and campus curriculum and to study how all disciplines on campus can utilize a campus farm as a space for exploration, learning, and individual growth. Beyond the disciplinary learning outcomes specific to each course participating in the Farm Hub program, overarching student learning outcomes of the PBEL pedagogical framework are as follows:

1. Applying iterative modes of inquiry and disciplinarily-appropriate methodologies to explore, reflect upon, and answer real-world questions.
2. Relating key environmental science concepts and their socio-environmental implications to local and global food systems.
3. Critically reflecting upon the impact of food production and individual food choices on environment, health, and society.
4. Effectively communicating the results and broader impacts of inquiry-based research to a cross-disciplinary audience.

Programmatic and student learning outcomes are currently being evaluated through surveys, focus groups, and course artifact analysis on the effect of place attachment and meaning on changes in scientific literacy and civic mindedness.

Steps to Develop PBEL Pedagogical Framework

The project team recruited four undergraduate instructors teaching biology, ecology, environmental studies, and chemistry courses to participate in the pilot development and implementation of campus farm-situated PBEL modules. These courses were selected because of the natural course content connections to sustainable agriculture topics. Upon agreeing to participate, each instructor reviewed their current course syllabus to identify topic areas that could be reframed in the context of local sustainable agriculture. A basic outline of the PBEL pedagogical framework was created and, during several revisions by the project team, criteria were added from experiential learning in agriculture education (Knobloch, 2003) and PBEL theory (Kolb & Kolb, 2012; Semken, 2005). The final draft of the framework was then sent to participating instructors for feedback on logistical feasibility in their courses. The final PBEL pedagogical framework (Appendix 1) was first used by the project team to develop four introductory lessons that offer real-world context to course modules, connect individual agency to global problems, and engage students in an active interaction with the campus farm space through a sensory reflection (https://www.butler.edu/cuefarm/learning-hub). While each instructor designed a module that best fit within their teaching style and discipline, they were required to utilize the pedagogical framework to deliver module content according to PBEL theoretical underpinnings. At quarterly project team meetings, instructors were encouraged to collectively brainstorm and collaborate with one another to generate curricular innovations.

Theoretical Foundation

In PBEL, hands-on, reflective learning is situated within the geography, ecology, sociology, and politics of a specific location, thereby connecting location with self and community (Gruenewald, 2003) to help students develop stronger ties to their community, enhance their appreciation for the natural world, and create a heightened commitment to serve as active citizens (Stedman, 2002). Through this "pedagogy of responsibility" (Martusewicz & Edmundson, 2005, p. 1) , students develop an ecological and community identity that enables them to actively reflect upon their lifestyles and consider their civic role and its impact to broader society (McInerney, Smyth, & Down, 2011; Smith & Sobel, 2014; Thomashow, 1996). This is aligned with John Dewey's (1938/2007, p. 22) assertion in his seminal book, *Experience and Education*, that the establishment of a sound learning environment in which each student can become invested in a shared "social enterprise" is of fundamental educational importance.

The experiential portion of PBEL is founded in a framework where a topic is iteratively explored in a particular environment (*concrete experience*), reflected upon to identify questions or problems of interest (*reflective observation*), experimentally tested via the design and execution of data collection (*abstract conceptualization* and *active experimentation*, respectively), and then reinterpreted with newly acquired knowledge (reiteration of *concrete experience*) to refine or open new lines of inquiry (reiteration of *reflective observation*) (Kolb & Kolb, 2012). As students iteratively move through this cycle, they learn to adapt their knowledge to the context of the environment (Kolb & Kolb, 2012).

Because all learning is a function of the environmental (i.e., locational) context in which it occurs, knowledge and skills are most effectively taught in locations in which students can actively apply them to a real-world context. However, in order to transform knowledge and understanding into a sense of responsibility and civic action, this connection to location must begin with a socially constructed and local 'place' to which students can grow attachment and ascribe meaning (Tuan, 1977). Place attachment and place meaning—a person's experiences and beliefs in a location (Ardoin, 2006) and the symbolic meanings that people give to places (Relph, 1976; Stedman, 2002), respectively—are collectively referred to as sense of place (Stedman, 2002). Driven by biophysical, psychological, sociocultural, and political-economic factors of a particular location (Ardoin, 2006; Kudryavtsev, Krasny, & Stedman, 2012; Stedman, 2002), sense of place changes through iterative learning (Solin, 2017) and inspires civic mindedness and environmental stewardship (Ardoin, 2014; Chapin III & Knapp, 2015). Due to the ecological and social interactions common to food production spaces and the "visceral connection" we all have with food (Solin, 2017, p. 10), campus farms provide a potent location in which students can learn about the role of food production and the impact of their personal choices to environment and society. By facilitating deeper connections to the campus farm as 'place', students move beyond experiential understanding of content to actionable civic mindedness, utilizing their knowledge and a new sense of responsibility to develop habits of caring and action (Figure 1).

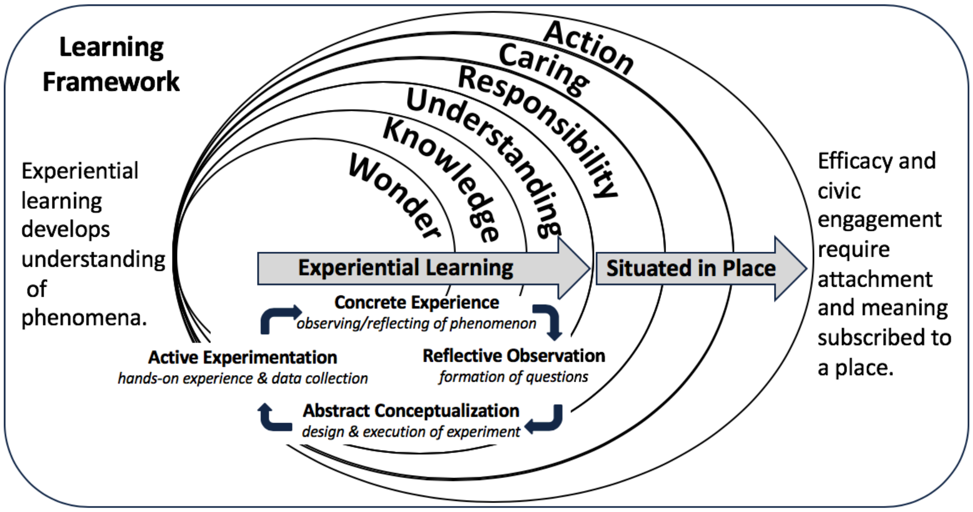

Figure 1. Schematic of place-based experiential learning (PBEL) framework. (Adapted from Kolb, 1984, figure 2.1, p. 21 and Sustainable Schools Project, 2016).

In order to create an environment that fosters deep place attachment and meaning to a location (i.e. a campus farm), our framework modifies the "five essential characteristics of place-based geoscience education" (Semken, 2005, p. 153) and incorporates it into the experiential learning context. For example, all Farm Hub modules are required to:

1. Provide a broad introduction to sustainable or local agriculture that includes the *diverse meanings of the farm space for instructor, students, and community*; socio-political and environmental aspects of agriculture; and the role of the campus farm in the local food system.
2. Define a sustainable or local agriculture sub-theme that is tied to an *authentic, real-world problem*.
3. *Facilitate attachment and meaning to place for life-long learning*, with a minimum of 4 hours of class or individual time interacting with the campus farm.
4. *Frame the module in PBEL theory* to enhance critical thinking skills and content exploration via active inquiry.
5. *Promote personal and civic responsibility for the place by* debriefing students via reflective questioning on what happened, what was learned, and how acquired knowledge inspires a personal change.

Use of the PBEL Pedagogical Framework in Practice

Applying the Framework to Pedagogical Practice

The resulting pedagogical framework consists of eight constructs: 1) Module Organization (sub-constructs: Introductory Lesson and Research Project), 2) Motivating and Engaging Context, 3) PBEL Theory, 4) Teamwork, 5) Communication, 6) Scientific Habits of Mind, 7) Civic Engagement, and 8) Formative and Summative Assessment. Each of these constructs has a number of criteria on which the modules were developed and assessed. Thirteen criteria across the eight constructs were required for the modules to align with programmatic expectations of the Farm Hub program (i.e., fidelity, designated with asterisks in the framework—see Appendix 1) and the remaining 21 criteria established pedagogical best practices for PBEL.

Instructors were tasked with creating a module plan by answering a series of detailed questions and checking their module curriculum against the provided framework to ensure the development of effective PBEL modules. For *The Introductory Lesson* sub-construct, instructors could create their own or utilize pre-designed lessons developed by the project team that were aligned with that sub-construct. Module plans were submitted by participating instructors, assessed by the first author and the advisory board for formative feedback, refined by instructors to improve fidelity, and finalized into a module plan to guide instructors in implementation.

This framework was subsequently operationalized into a protocol that scored 31 criteria—housed within seven of the eight thematic areas—on a five-point 'Likert' scale from 'Not present' (score = 0) to 'Excellent' (score = 4). Thirteen criteria were required for the modules to align with the program's goals, i.e. programmatic fidelity, and the remaining 18 criteria established best practices for PBEL pedagogy. The "Formative and Summative Assessment" construct was not observationally assessed because the criteria located beneath it were more productively identified through the analysis of course artifacts (e.g., syllabi, assignment instructions/descriptions, student submissions). Using the protocol, *intended* programmatic fidelity and adherence to PBEL best practices were quantified for each module plan prior to implementation via content analysis. Of the few studies that have sought to measure fidelity of implementation (i.e., *applied* fidelity), student artifact analysis and instructor self-report measures (e.g., instructor interviews or surveys) are the most commonly used methods (O'Donnell, 2008), while observational methods are underutilized (see exception Vaughn et al., 2006). However, self-report measures consistently reported higher fidelity than observational results (Emshoff et al., 1987), suggesting that they may not accurately represent reality. Therefore, *applied* programmatic fidelity and PBEL best practice adherence during implementation was quantified primarily using observational methods and secondarily informed by instructor interviews. Researchers observed every class session where PBEL modules were implemented and recorded extensive notes on instructional activities. At the end of the semester, researchers conducted self-report interviews with the instructors to ensure that unobserved times when critical components of the farm-situated PBEL taxonomy were included in the analysis. Observation notes from each class session were compiled for each course, combined with self-report documentation, and used to score *applied* fidelity using the protocol.

An Example

Here we present preliminary outcomes of two courses that used the PBEL pedagogical framework to design and implement farm-situated PBEL modules in fall 2017 courses: an introductory course in environmental studies (mostly sophomore majors and minors) and an introductory biology course (mostly sophomore majors). Each course is detailed below:

1. <u>Environmental Studies:</u> To become familiar with global food system issues, students read, reflected upon, and discussed Michael Pollen's *The Omnivore's Dilemma* and completed an introductory lesson that included a screening of FRESH the movie, an exercise quantifying the carbon footprint of a day's worth of meals, and a sensory reflection on the campus farm. Utilizing ethnographic methods at the campus farm and

other local urban farms in Indianapolis, students localized readings and discussions to answer the driving question: *What factors influence farmer perspectives on the policies and practices for establishing sustainable local food economies?* Qualitative data were then interpreted using course concepts culminating in a research paper and presentation.

2. Biology: General topics of soil respiration and biodiversity were framed in the context of agriculture through the following research question: *In what ways do sustainable, urban farms enhance urban ecosystem function and contribute to a more balanced food system?* By combining biological concepts, socio-environmental impacts of local and global food systems, and applied research, students explored this question and the importance of soil activity and biodiversity for food production through the experimental testing of hypotheses comparing soil respiration and arthropod diversity in a variety of macro- and micro-habitat types. Students statistically interpreted their findings and presented results at a cross-disciplinary poster session with other university courses.

In both courses, *intended* fidelity and best practice adherence to the PBEL pedagogical framework was higher than *applied* fidelity and best practice adherence during implementation (Table 1). The biology course had significantly lower *applied* implementation fidelity and best practice scores than the environmental studies course (Table 1). Preliminary results are presented below that suggest the efficacy of the PBEL framework in increasing place attachment and meaning to the farm space, civic mindedness, and scientific literacy. Research is underway linking PBEL framework fidelity and best practice adherence to these student learning outcomes.

Table 1. ***Intended*** *and* ***applied*** *program fidelity and PBEL best practice adherence scores.*

Course	**Module Plans (*intended*)**		**Module Implementation (*applied*)**	
	Fidelity Score	**Best Practices Score**	**Fidelity Score**	**Best Practices Score**
Biology	52/52	117/124	28/52	64/124
Env. Studies	48/52	120/124	40/52	94/124

Place attachment and meaning, civic mindedness, and scientific literacy were quantified via optional surveys that were distributed to students enrolled in each course via email. Change in place attachment was determined using an 11-item, five-point Likert scale survey instrument with two sub-constructs: place identity and place dependence (Williams & Vaske, 2003). To measure change in place meaning specific to a campus farm space, i.e., the extent to which students understand and relate to a space through a lens of sustainability, a new survey instrument was designed using prior literature on place meaning scales (Kudryavtsev, Krasny, & Stedman, 2012; Stedman, 2002, 2003; Young, 1999). The civic-minded graduate (CMG) scale, which seeks to measure the knowledge, skills, dispositions, and behavioral intentions related to civic-engagement (Steinberg, Hatcher, & Bringle, 2011), was used to quantify civic mindedness. Scientific literacy was evaluated using the Test of Scientific Literacy Skills survey instrument (Gormally, Brickman, & Lutz, 2012).

A pre-survey was emailed to students during the first week of classes and a post-survey during the second to last week of classes. During module plan development (2016), instructors taught their courses per usual, with no PBEL module implementation and baseline surveys were completed by students enrolled in the courses (Note: since courses did not engage with the campus farm pre-implementation, baseline place attachment and meaning was not assessed). In implementation years (2017 presented here), pre- and post- surveys were distributed with the same timing during the semester and included place attachment and meaning surveys. Student focus groups for each course were also held during the second to last week of classes to gain a deeper understanding of student experiences with the farm-situated PBEL modules.

With a higher *applied* fidelity and best practices adherence than the biology course, the environmental studies course showed significant improvements pre-to-post-module in place attachment ($t(18)=-4.414$, $p<0.000$) and place meaning ($t(18)=-2.276$, $p<0.0175$) subscribed to the farm space and whereas the biology course, with lower *applied* fidelity and best practices adherence scores, showed no statistically significant improvements in pre-to-post-module place attachment and meaning ($t(9)=-1.262$, $p<0.120$ and $t(9)=-1.585$, $p<0.0735$, respectively). Accounting for differences in civic mindedness scores for baseline (pre-implementation) years, the environmental studies course had significantly greater overall civic mindedness scores after module implementation than the biology course (between course: $t(33)=-4.920$, $p<0,000$)). Linear regression analysis suggests that higher place attachment and meaning scores have significant predictive power over civic mindedness scores, with a model comprising post-place meaning, post-place attachment, and course explaining 56.6% of the civic mindedness score variance ($R^2=0.596$, $F(3,41)=20.153$, $p<0.01$).

Only the biology course showed significant improvements pre-to-post-module implementation in overall scientific literacy (environmental studies: $t(13)=-0.-789$, $p=0.444$; biology: $t(7)=-2.826$, $p=0.026$). The TOSLS survey instrument used to assess scientific literacy focuses primarily on analysis and interpretation of quantitative data (61% of survey questions) and, therefore, our findings may not be appropriate for short sections of courses, courses focusing upon a narrow scientific area, or courses with primarily qualitative methodologies. Combined, these results indicate that fidelity to the PBEL framework matters for these student learning outcomes.

A second year of implementation is currently underway for these two courses and two additional courses are, for the first-time, implementing modules that were developed using the framework. Data collection to quantify changes in student place attachment, place meaning, and civic mindedness will continue using the same instruments. In future years, a more focused instrument will be utilized in lieu of the current instrument—Test of Scientific Literacy Skills (TOSLS)—to quantify changes in environmental science literacy and scientific reasoning. This data will be applied to understand explicit connections between the PBEL framework and student learning outcomes, culminating in a formal pedagogical taxonomy for farm-situated PBEL curriculum that can be applied in courses from a wide range of disciplines.

Conclusion

By using the PBEL pedagogical framework and accompanying introductory lessons, instructors—with little to no prior knowledge of agricultural content or PBEL theory—developed and implemented impactful research modules centered upon the common theme of local sustainable agriculture in biology, ecology, environmental studies, and chemistry courses. For module implementation, the framework was converted to an observation protocol to quantify *applied* implementation fidelity to the program (13 required criteria) and adherence to PBEL best practices (remaining 21 criteria). This protocol has been, and will continue to be, utilized to refine teaching methods and—combined with student learning outcomes on environmental science literacy, scientific reasoning, place attachment and meaning, and civic mindedness—drive the development of a taxonomy, which will include the criteria most integral to positive student learning outcomes in PBEL contexts. Future applications will test efficacy of this approach in non-science courses including communications, business, primary education, religion, and nutrition, at other institutions, and in other 'place' settings.

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Appendix A
Place-based Experiential Learning (PBEL) Framework

As part of your participation in the NSF-IUSE program, you have agreed to create and implement a 4–6-week place-based, experiential learning research module thematically set within the context of sustainable agriculture. For our purposes, a module is defined as a unit or topic area with multiple lessons that span introductory material, data collection, statistical analysis (if applicable), and reporting. Lessons may take place in lectures, discussions, labs, independent projects, homework, or any combination of these formats.

Place-based experiential learning (PBEL) underpins hands-on learning with the specific geography, ecology, sociology, and politics of a location. PBEL strives to connect location with self and community to help students develop stronger ties to their community, enhance their appreciation for the natural world, and create a heightened commitment to serve as active, contributing citizens[1-4]. The experiential learning portion of PBEL is founded in a theoretical framework where a topic or pattern is iteratively explored in a particular environment (*concrete experience*), reflected upon to identify questions or problems of interest (*reflective observation*), experimentally tested via the design and execution of hands-on data collection (*abstract conceptualization* and *active experimentation*, respectively), and then reinterpreted with newly acquired knowledge (reiteration of *concrete experience*) to refine or open new lines of inquiry (reiteration of *reflective observation*)[5].

Experiential learning theory centers upon the environmental context in which a problem is studied to create knowledge and understanding. However, to move students beyond understanding to civic action, the environmental context must encompass a socially constructed and local 'place' to which students are attached and subscribe meaning.[8] By facilitating deeper connections to 'place', students develop an ecological and community identity that allows them to reflect on the impact of their lifestyles and better understand the impact their knowledge generation has on real people and their localities. This sense of place is the essence of PBEL theory.

This framework provides flexibility to the instructor, while ensuring a cohesive program founded in PBEL theory that can be effectively researched[5-7]. Each instructor is required to include the following four items in their module, with items #1 and #2 provided by the program director and project team. The introductory lesson[A] strives to set a foundation for a strong attachment and meaning to 'place' by providing a personal, local, and global connection to food through on-farm experiences and discussions of global/industrial and local/sustainable food systems[B]. The research project should also play an integral role in subscribing meaning to 'place' through farm and community ties.

Provided to Instructors

1. Overview of CUE Farm ground rules.
2. Introductory lesson[A] on social, ecological and individual impacts of global/industrial and local/sustainable food systems[B]. These lessons are made up of 3 parts:
    a. 10-minute sensory reflection on the CUE Farm
    b. Carbon footprint of a meal homework assignment

c. Interactive introductory activity

Developed by Instructors

3. Sustainable agriculture research project conducted on the CUE Farm or another farm.
4. Cross-course poster session to peers and external community members.

[A] *Instructors can opt to develop their own introductory lesson as long as it covers social, ecological and individual impacts of global/industrial and local/sustainable food systems.*

[B] *A food system includes all processes, infrastructure, and resources involved in feeding a population: growing, harvesting, processing, packaging, transporting, marketing, consuming, and disposing of food and food-related items. A food system operates within and is influenced by social, political, economic and environmental contexts. Food systems are typically defined as global/industrial or local/sustainable their model of production.*

When developing the module, each instructor should strive to meet the items listed in the below framework throughout the 4–6-week curriculum. While each module may not accomplish all of the items listed, adequate coverage of these items will ensure that modules address the overall goals of the program to enhance scientific literacy and civic mindedness through attachments to place. **PLEASE NOTE: Required items are preceded with a double-asterisk.** The IUPUI STEM Education Research and Innovation Institute (SEIRI) will also convert this framework into an observation protocol to assess module implementation during in-class observations.

FRAMEWORK (Please Note: Required items are preceded with a double-asterisk **).

Construct 1: PBE Module Organization
Present clear objectives and learning goals to students at beginning of module.
Include lessons that flow in a logical and sequential order so they build on each other (**a suggested order of lessons follow**).
The Introductory Lesson
**Brief students at the beginning of the introductory lesson (i.e. connect to lecture/reading topics, emphasize the purpose of the lesson and what can be learned/why it is important, encourage students to think about the lessons in relation to their own lives in the food system).
**Include basic rules of behavior on the CUE Farm. *(list provided)*
**Incorporate a 10-minute sensory reflection on the CUE Farm as part of the introductory lessons *(reflection provided: https://www.butler.edu/cuefarm/learning-hub)*.
**Implement an introductory activity that contextualizes the environmental, social, and individual aspects of the global/industrial versus local/sustainable food systems *(activity provided, if desired: https://www.butler.edu/cuefarm/learning-hub)*.
**Include the eatlowcarbon.org homework assignment *(assignment provided: https://www.butler.edu/cuefarm/learning-hub)*.
**Debrief students at the end of the introductory lesson (bring group back to main point of the lesson, reflective questioning on what happened, what did they learn, and how their acquired knowledge inspires them to change their own interaction with the food system).
The Research Project
**Brief students at the beginning of the research project (i.e., connect to introductory lesson,

emphasize the purpose of the research and what can be learned/why it is important, encourage students to think about the lessons in relation to their own lives in the food system).
**Introduce an inquiry-based 4–6-week research project that spends a minimum of 4 hours on the CUE Farm or another urban farm to establish a contextualized setting for students to learn.
**Debrief students at the end of the research project (i.e., bring group back to main point of the research project and entire module, reflective questioning on what they learned, how the learning helps the local food system, and how their acquired knowledge inspires them to change their own interaction with the food system).

Construct 2: A Motivating and Engaging Context
Promote a coherent conceptual understanding of the social, ecological, and individual impacts of global/industrial and local/sustainable agriculture.
Provide a local context that connects the CUE Farm or another local farm to broader food system challenges.
**Present a real-world research question related to agriculture with a compelling purpose (what, why, and for whom) on which the students can base inquiry.

Construct 3: PBE Theory
**Engage students on the CUE Farm or another urban farm for a minimum of 4 hours during lessons, research projects, lectures, homework, or other class-related activities.
**Include opportunities for students to conduct real-world applied research that involves collecting and analyzing information or data before arriving at a solution.
Connect the research project to core concepts taught in the introductory lesson and class lectures/readings.
Require students to use fundamental scientific process concepts to solve research questions.
Engage students in discussions and activities to help them understand and consider their role in the food system.

Construct 4: Teamwork
Require students to collaborate with others.
Provide opportunities for students to demonstrate individual responsibility.

Construct 5: Communication
Challenge students communicate research outcomes to others using appropriate content language (e.g. verbally, in writing, or in visual aids such as charts or graphs).
**Require students to communicate research outcomes and their impact to the local Indianapolis food system via an end-of-semester poster session.

Construct 6: Scientific Habits of Mind
Engage students in scientific habits of mind (e.g., systems thinking, creativity).
Expect students to utilize scientifically valid literature and evaluate existing data to inform their research.
Challenge students to pose and interpret a scientific argument, including potential confounding factors.
Encourage students to use or interpret basic statistics and graphing for information analysis, problem solving, and/or decision-making.

Construct 7: Civic Engagement
Raise awareness of the social and political issues surrounding the food system including the misuse of scientific information.
Provide contextualized knowledge and skills that prepare students to engage in real societal problems.
Create a discourse that fosters the development of student values to engage in society's challenges.
Empower students to realize that their personal and professional choice matters.

Construct 8: Formative and Summative Assessment
Assess student learning outcomes through assignments that are closely aligned with the learning objectives and content.
Allow students to demonstrate their understanding and abilities in different ways.
Assignments and feedback inform the instructor on how to improve module implementation.

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