

Teaching STEM through Horticulture: Implementing an Edible Plant Curriculum at a STEM-centric Elementary School

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Abstract

School gardens are ideal places for students to ask and answer questions about science. This paper describes a case study of two 3rd grade teachers and two STEM coordinators who were recruited to implement and evaluate a horticultural-based curriculum developed for this study. U Informed by the Teacher-Centered Systemic Reform model we conducted a case study analysis of the beliefs and practices of these four educators. Teachers made curricular decisions based on their confidence teaching about plants, the accessibility of curricular materials, perceptions of relevancy of lessons to academic science standards, and the time constraints. One STEM coordinator reported that the curriculum addressed academic science standards, was relevant to students' lives, and provided hands-on inquiry activities connected to the school garden. The subsequent STEM coordinator, along with the teachers, believed that garden plants do not address science standards and instead support enrichment activities. We conclude that professional development on horticultural-based curriculum for both teachers and STEM coaches is warranted.

Keywords: horticulture, curriculum, elementary teachers, STEM

Introduction

Science, technology, engineering, and mathematics (STEM) concepts engage students when presented through curricula requiring students to explore authentic issues (Zeidler, Sadler, Simmons, & Howes, 2005; National Research Council [NRC], 2012). For example, prompts such as, “where does our food come from?” are meaningful because they initiate discussions about the production of food and fiber, making science content relevant and connecting to students' lives (Baker, Bunch, & Kelsey, 2015). In the process, teachers can address students' agricultural literacy, during discussions or lessons about food and health.

According to the National Institute of Food and Agriculture an increased knowledge of agriculture and nutrition is needed for people to make informed food choices about diet and health (USDA NIFA, 2012). However, to understand how quality and quantity of food can affect health young people need to know where food originates and how to make decisions about what to eat, knowledge that increases one's agricultural literacy. Agriculturally literate adolescents are able to “a) engage in social conversation, b) evaluate the validity of media, c) identify local, national, and international issues, and d) pose and evaluate arguments based on scientific evidence” as it relates to “agriculture, food, fiber, and natural resource systems.” (Meischen & Trexler, 2003, p. 44). Schools are ideal places to increase students' agricultural literacy especially when teachers use

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school gardens that are integrated into the curricula and can help students make personal decisions about diet and nutrition.

Horticultural and garden-based curricula have promise for helping elementary students explore the four core subjects: science, mathematics, language arts, and social studies, while teaching them about the origin and production of food crops (Williams & Dixon, 2010). More broadly, Mabie and Baker (1996) found that participation in agriculturally oriented experiential activities positively impacted the development of science process skills of elementary students. Elementary teachers generally believe that agriculture is a viable tool that can be integrated across disciplines, if the resources meet standards-based learning targets across disciplines (Bellah & Dyer, 2009), but materials that center on the agricultural industry alone are reportedly less attractive to teachers (Knobloch, 2008). Hands-on gardening curriculum, such as the Junior Master Gardener curriculum from Texas A&M University, though, has been found to be successful in increasing students' interests in pursuing agricultural careers (Meyer, Hegland, & Fairbourne, 2001; Dirks & Orvis, 2005), but not necessarily increased knowledge of diet and nutrition. Several studies have examined the positive role that school gardens can play in addressing students' understanding of both where food originates and plant science content (Murphy, 2003; Graham & Zidenberg-Cher, 2005; Koch, Waliczek, & Zajicek, 2006; McAleese & Ranklin, 2007). Klemmer, Waliczek, and Zajicek (2005) found that third to fifth grade students scored significantly higher on science tests after participating in school gardening activities compared to peers without such experiences. Likewise, Murphy (2003) found, more broadly, that participants in a California school garden program experienced significant gains in their overall math and science grade point averages.

The constraint that many schools and teachers face, though, as we found in our own community, is the practical issue of maintaining school gardens. Many gardens are seeded in the spring, and if there are no volunteers or workers to maintain the gardens over the summer and holiday months, they are not in the shape needed for teachers and students to work in when school resumes in the fall. If teachers use horticultural-based lessons as tools to help their students learn science, agriculture, and health, schools need access to resources that are not dependent on outdoor gardens. In addition, whether teachers perceive horticultural-based lessons as way to address science standards warrants further examination.

Conceptual Framework

To better understand how teachers respond to curricular resources introduced during professional development efforts the use of the Teacher-Centered Systemic Reform (TCSR) model is appropriate (Woodbury & Gess-Newsome, 2002). The TCSR explains the relationship between contextual/ infrastructural factors and teacher beliefs/ practices. Drawing on Bandura's (1977) social cognitive theory, which predicts that knowledge, skills, and attitudes are driving forces that influence behaviors, the TCSR model is grounded in the assumption that teacher practices can be explained by teachers' beliefs situated within an environment (i.e., their respective school contexts). Woodbury and Gess-Newsome (2002) argued that teacher beliefs, in the context of school, local, regional, and national concerns, can help researchers and administrators better understand why some reform efforts are successful and others are not. It has been suggested that teacher beliefs are stronger predictors of teacher practices than teacher knowledge (Pajares, 1992) and, therefore, are important when evaluating teacher reform efforts.

Researchers have shown that the adoption of reform efforts by teachers can be complex. Lotter, Harwood, and Bonner (2007) found that teacher beliefs about the role of education and instruction influenced teachers' receptivity to reform efforts, such as inquiry-based teaching. Although teachers may support reform efforts, the culture of the school (including administrators' expectations) may hinder the success of the reform. Davis (2001) called on educational reformers to explicitly identify power structures in schools and ways to empower teachers to be closely

involved in reform efforts before initiating any new programs. School-wide complexity, therefore, including teacher beliefs and attitudes about teaching expectations and instructional approaches, can explain the success or lack of success in teachers' adoption of new curricular or pedagogical approaches (Southerland, Smith, Sowell, & Kittelson, 2007).

Past studies and analyses of successful reform efforts can be informative. Although successful school reform relies on several contextual factors, Wilson (2013) summarized these into the following five themes: (a) duration; (b) active learning; (c) collective participation (from faculty and administration); (d) coherence with policy and accepted practices; and (e) content focused. For example, Loucks-Horsley, Hewson, Love, and Stiles (1998) found that teachers are more likely to use new curricular resources if they have concurrently received authentic inquiry-based professional development helping them with implementation. Likewise, Akerson and Hanuscin (2007) found that reform efforts are successful when professional development providers consider contextual factors. In their study of science inquiry professional development designed for elementary schools, they reported that reform projects should: a) be sustained and long-term, b) include on-the-job mentoring of teacher practice, c) allow opportunities for teachers to debrief and share their experiences, and d) include both project staff and teacher goals (Akerson & Hanuscin, 2007). The TCSR model is consistent with the findings of both Wilson (2013) and of Akerson and Hanuscin (2007). Specifically, the TCSR helps researchers consider *personal* or *structural/cultural* factors that may influence teaching practices.

Purpose and Research Question

The purpose of this study was to study how elementary teachers at a STEM-centric elementary school *perceived* and *integrated* the Edible Plants Curriculum (EPC) into their existing curriculum.

Methods

Our study employed a case study methodology. Case study research can enhance the theory generating capability of the case and also support the validity of the assertions made by the participants in the case and the researcher's perceptions (Stake, 2005). Documenting that similar findings related to a question originate from different collection methods is effective in managing the subjectivity of the researcher's observations and allows the case to speak for itself (Stake, 2005). Our case study focused on a single entity (a STEM-centric elementary school) as an instrumental example of an elementary school. Several data sources were collected as we sought to ensure that propositions could be drawn from the case.

Context

The study was conducted at an elementary school in the western United States. The school administration and staff decided to focus on STEM curricula six years ago and was officially designated a STEM-centric school by the school board in 2013. The decision to become a STEM-centric school was initiated by a former principal of the school (a former president of the National Elementary School Principal Association), who is the spouse of an agricultural scientist/administrator at a land grant university in the same community. The school staff and faculty wanted: 1) to address national concerns about science and mathematics literacy of its students and 2) to increase enrollment through the district's "school of choice" policy. Since the adoption of the STEM-centric focus one of the authors (MB) has been involved in supporting teachers through professional development programming over the past six years.

The elementary STEM school model is not well defined in the literature. This particular school's mission is to develop a model for school-level integration of STEM. Their model for instruction, programming, and school culture is consistent with the larger STEM initiative. They

use the *Next Generation Science Standards* (NGSS Lead States, 2013) and the *Framework for K-12 Science Education* (NRC, 2012) to guide their STEM goals. A STEM coordinator (Anna, pseudonym) was hired to facilitate the integration of the program. Her BS degree in Environmental Science, M.A. in Education, and Ph.D. in Educational Leadership gave her the necessary background to promote student and parent involvement in STEM activities, thus fostering students' STEM identities ("increased competencies and confidence," as she explained). Anna left the school following her family out of state before the EPC could be implemented. A second STEM coordinator, Susan (pseudonym), was hired who had a BA degree in elementary education and an M. Ed. in environmental education, and experience as both a formal and informal educator.

The school showcases two visible projects to illustrate their commitment to STEM education. First, an annual event called STEM Night is an opportunity for community members, students, and teachers to highlight engaging STEM activities. The two-hour event regularly draws 500-700 people each year. Second, the school maintains a garden that is maintained by teachers, parents, and students. A parent group maintains a website ("Stems of Learning") and documents how teachers and students use the garden to support learning. The teachers are not required to use the garden but are encouraged to do so by administrators and parent volunteers. Each year the third grade students use part of the garden for their "pizza garden." The school typically has around 330 K-5th grade students enrolled each academic year. The school is in the center of town and serves a mixed income population. At the time of the study sixteen percent of the students were classified as English Language Learners and qualified for free and reduced lunch. This school is also designated as the district's autism elementary school, providing resources and trained staff for students on the autism spectrum.

Participants

Through our relationship with the school we became aware of several teachers' interests in school garden curricula. The EPC was developed for upper elementary (grades 3-5), and those teachers (n=6) were invited to evaluate the curriculum materials. The two third grade teachers (Melissa and Elizabeth, both pseudonyms) chose to implement lessons. Melissa is licensed to teach elementary and middle school in two states and had been teaching for about 10 years at the time of the study, is highly qualified to teach K-8 mathematics, and loves history. Elizabeth is licensed in early childhood education (PK-3) and had taught for only one year at the time of the study. Elizabeth loves cooking and hiking. Melissa was assigned to be Elizabeth's mentor and the two appeared to get along with one another. Both Melissa and Elizabeth grew up in urban areas, as did one STEM coordinator (Susan). The first STEM coordinator (Anna) is an active gardener and grew up in a small town (<8,000 people).

Curriculum development

We used two curricular frameworks to develop the EPC: Understanding by Design (UbD) and Project-based learning (PBL). UbD is a model to help teachers design curricular modules using three learning stages: 1) learning goals, 2) assessment, and 3) learning plan (Wiggins & McTighe, 2005). UbD, also called "backward planning," allows educators to be purposeful and intentional in designing instructional and assessment activities. We referred to the Next Generation Science Standards, CCSS, and state academic standards as we designed our learning objectives. Second, our lessons centered on problem-solving skills and students' "desire to know" (Barron & Darling-Hammond, 2008). PBL begins by asking students to solve a problem or answer a loosely framed question to encourage them to consider what content and skills are needed to solve the problem and/or answer the question (Barron, Schwartz, Vye, Moore, Petrosino, Zech, & Bransford, 1998).

The curricular materials were developed over a year. An advisory group that included experts in elementary teaching, teacher education, curriculum development, and agricultural

science provided input as materials were developed. Two science/ health curriculum coordinators from the local school district were consulted during this process. They provided feedback on organization/layout, language, worksheets, access to resources, and levels of alignment between assessments and learning objectives. More details on the development process and links to online resources are published elsewhere (<https://dspace.library.colostate.edu/handle/10217/82598>).

Data Collection

Eight sources of data were collected: 1) observational field notes; 2) video transcripts of lesson implementation; 3) formal interviews with teachers; 4) curriculum evaluation tool for teachers; 5) formal interview with STEM coordinator; 6) school website; 7) informal interviews with school community members; and 8) student artifacts from the lessons. Of these, the first three data sources were most important in generating propositions about teachers' perceptions of using EPC in their classes. The first author (LG) transcribed 135 minutes of video recording of instruction. The other five data sources served as triangulating data sources.

Observational Field Notes. Field notes were collected during classroom interventions, STEM Nights over three years (2011-2013), and informal interviews with parents and the principal during school visits. When teachers implemented lessons, LG was a participant observer and recorded notes on how the teacher interacted with students, the types of questions and comments that students exhibited, and the flow of the lesson. These lessons were video-recorded and notes were compared to video transcripts to ensure that inferences made could be corroborated with other comments and actions. We interacted with parents and others during the STEM Night. Informal interviews with the principal, parents, and teachers were conducted each time we visited the school. After each visit field notes were recorded with special attention to how staff described STEM and questions about plant science.

Video analysis of lesson implementation. Both Melissa and Elizabeth reviewed the EPC website and selected parts of lessons from the tomato and potato units to implement. Melissa had 33 students, and Elizabeth had 25 students who participated in the lessons. Although there was no official training of the curriculum materials, we answered all teacher questions prior to implementation. Both Melissa and Elizabeth taught the lessons while one member of curriculum development team was present and set up a video recorder in the back of the room and took notes. The school's STEM coordinator, two gifted and talented paraprofessional educators, one parent volunteer and one co-author observed the interventions. Videos of the classroom interventions (168 minutes in total) were transcribed for analysis.

Formal Interviews. Teachers were interviewed after each intervention on the same day using semi-structured prompts. Each teacher was asked the same questions but was asked to expand based on their individual responses. The purpose of the interviews was to determine the teachers' perceptions of the curricular materials, as well as their perceptions of how they could best meet their STEM learning objectives. Questions asked were:

1. Was the EPC "teacher friendly?" Please explain.
2. Do you believe the unit or lesson plans need modifications? If so, how?
3. Would you choose to implement only some lessons and not others? Please explain.
4. If you did implement a lesson, please explain why you chose it.
5. Would you recommend this curriculum to other teachers? Please explain.
6. Please explain if the unit and lesson plans were designed in a way that you liked or not.

Teacher curriculum evaluation tool. Teachers were invited to use an evaluation tool that accompanied the curricular materials found online to provide feedback on the curriculum. The

evaluation tool was designed on a dichotomous scale, but allowed teachers to add comments. Six teachers at the school anonymously responded. The evaluation tool was reviewed by two evaluation experts: a researcher whose specialty is educational evaluation and the associate director of the university STEM Center. We were interested in teachers' perceptions of the effectiveness of the curricular materials in meeting grade specific reading, writing, and mathematics Common Core State Standards (CCSS), life science (agricultural content), comprehensive health standards (nutrition content) as well as 21st century inquiry-based skills. During the post-intervention interviews Melissa and Elizabeth and the two STEM coordinators were asked to evaluate whether they felt each standard was met when they conducted the activity during the intervention. The interviews were audio recorded and transcribed for analysis.

Interview of the STEM coordinator(s). Both STEM coordinators (Anna and Susan) were interviewed using a semi-structured format. The interview protocol followed the same prompts used for the teacher interviews and these data were used to help corroborate other findings. The STEM coordinators' role was to help teachers integrate STEM in as many ways as possible into daily instruction. The second STEM coordinator, Susan, was interviewed when teachers taught the lessons. Interviews were audio recorded and transcribed for analysis.

School website. The school website described the school's mission, philosophy, and approach to teaching STEM. The "Stems of Learning" blog that faculty and staff members use to keep the school community up to date on their school garden efforts was also reviewed.

Informal meetings with school community members. Two enrichment teachers and a volunteer parent who attended the lessons and assisted throughout the curriculum activities provided feedback informally during and after lesson implementations. Discussions with parents, students, and other teachers as well as the principal during STEM Nights provided more input on student perceptions of garden and agriculture-based curriculum. Interview notes and reflections were recorded immediately following the informal interviews.

Student lesson artifacts. Teachers collected student artifacts/ assessments after each of the interventions. These were reviewed for any changes or edits teachers made to the original EPC assessments (e.g., the teachers replaced a black and white map with a more colorful map).

Data Analysis

Constant comparative coding was used to analyze the observational notes, informal and formal interviews, and videos (Strauss & Corbin, 1990). Comparing and contrasting the responses and comments of the different participants enabled us to identify and bind categories, assign segments to categories, summarize the content of each category, find negative evidence and discover the patterns used to articulate the findings (Tesch, 1990). Cross verification from two or more independent sources was used to confirm the validity of each finding in the study (Patton, 2002). As Charmaz and Belgrave (2012) described, for constructivist analyses it is difficult to use a theoretical framework to inform coding and to simultaneously engage in truly unbiased coding. Rather, constructivist researchers are open and sensitive to phenomena that will help them answer their research questions. Thus, the TCSR model served as a "sensitizing concept" as we identified our final axial codes (Charmaz & Belgrave, 2012).

Open codes regarding the participants' verbal and instructional responses to the curriculum were categories into two selective codes: *incentives* and *barriers* (see Table 1).

Table 1

Coding categories identified during qualitative case study analysis of two third grade teachers' beliefs.

Open Codes	Selective Codes	Axial Codes
Cost	Incentive	Structural/Cultural
Resource availability (designed as kit)	Incentive	Structural/Cultural
Connection to school activities (garden)	Incentive	Structural/Cultural
Connection to nutrition literacy	Incentive	Structural/Cultural
Connection to other core discipline academic standards	Incentive	Structural/Cultural
Continued access to resources uncertain	Barrier	Structural/Cultural/Personal
Connection to science standards	Barrier	Structural/Cultural/Personal
Time needed to teach	Barrier	Personal
Classroom management concerns	Barrier	Personal
Teacher confidence	Barrier	Personal

Incentives for using an horticultural-based STEM curriculum included: 1) cost (free online availability of curricular resources), 2) accessibility to in-class resources (such as planting materials), 3) a clear school-garden connection (afforded opportunities for students to make connections between in-class lessons and other school resources), 4) reinforcement of nutrition literacy (an expectation of the school district), and 5) standards-focus (expectations of the school, district, and state). The *barriers* that teacher perceived included: 1) resource intensive (cost and availability of planting materials); 2) time (growing plants takes time), 3) time conflicts with other standards (perceptions that garden or edible plant-based lessons do not support STEM initiatives), 3) classroom management (concerns and abilities to manage students who are engaged in lessons with which teachers have little experience), 5) confidence (participants expressed low levels of confidence regarding gardening skills and knowledge about plants). The selective codes were then collapsed into axial codes that were informed by the TCSR model and organized by contextual level (see Table 1; Woodbury & Gess-Newsome, 2002).

Establishing Trustworthiness

In response to Williams and Dixon's (2013) call for rigor in garden-based research studies, we were purposeful in our efforts to ensure trustworthiness. Our team participated in regular peer debriefing, ensured prolonged engagement within the research setting and with participants, determined inter-rater coding reliability, and engaged in member checking (Creswell, 1998). The participating teachers participated in a member-checking interview after initial analyses of the data and confirmed our propositions. Our findings were shared with the principal, who also concurred with the findings. We used multiple data sources to triangulate our findings, but our primary data sources were the observational field notes, video transcripts, and teacher interview transcripts. The first author trained a another author, who coded an entire teacher transcript, on the coding scheme. Both authors' codes were compared and any discrepancies were discussed and resolved (Kurasaki, 2000) after which coding was completed.

Findings

Our analyses yielded two main findings. Our participants chose new curricular resources based on 1) their respective cost-benefit analyses and 2) their belief of whether or not lessons are related to STEM. Furthermore, STEM coordinators either reinforced (Susan) or challenged (Anna) the aforementioned views of the teachers (see Figure 1). The two teachers' cost-benefit analyses included their respective confidence levels to teach the curricular content, accessibility of curricular materials (cost and resource availability), perceived relevancy, and time constraints. Anna reviewed the EPC as it was being developed and believed that horticultural-based lessons provided an opportunity for teachers to address STEM standards through relevant, hands-on inquiry experiences. Susan, however, did not share this belief. She was the STEM coordinator at the time wh

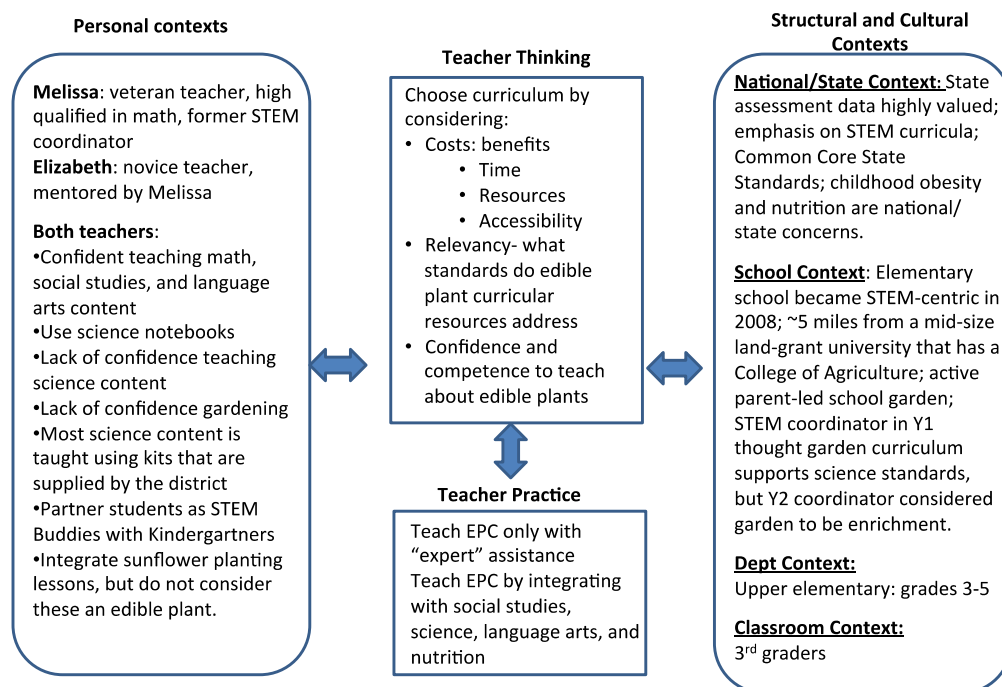


Figure 1. The teacher-centered systemic reform model (Woodbury & Gess-Newsome, 2002) was used to frame our case study analysis of teachers who implemented the Edible Plants Curriculum (EPC).

Determining the Cost and Benefits of Curricular Resources

The incentives to teach lessons were driven by school, departmental, district, or state level contexts, whereas the barriers were driven by classroom or personal concerns. One initial departmental concern was costs of planting materials; however, this was addressed by the parent volunteer group's garden fundraising efforts. Analyses of several data (interviews, classroom observations during implementation of the EPC, field notes recorded during other instructional or school activities) revealed that participants weighed the pros and cons of their own *confidence* levels, the *accessibility* to curricular resources, the *relevancy* of the curricular resources to their standards-based learning targets, and the *time* needed to plan/ implement lessons.

Confidence. The teachers discussed gardening as a "special" activity. It was perceived as a tool that supported standards-based learning objectives but not those for science lessons. When

Melissa stated that she and Elizabeth were in charge of the pizza garden during the study, she indicated that the curricular choice of using the EPC was driven by contextual issues (feeling obliged to use a parent-run school resource), rather than because they wanted to teach about edible plants.

Neither Elizabeth nor Melissa were active gardeners and expressed a lack of confidence in teaching gardening-based lessons. They were unsure about teaching plant science. Melissa was comfortable sharing her lack of confidence with her students, "I have something known as a black thumb, the opposite of a green thumb. This is why we are so lucky to have [LG] with us here today." However, with some guidance, Melissa's confidence grew. She explained, "Now that I have seen you demo the planting portion of the lesson twice I would feel comfortable teaching that lesson." She told her students that expertise is needed to garden. Rather than just conveying the information, she indicated that the expert guest was more knowledgeable than she,

[our guest] is going to tell us how much soil we need. She's going to tell us how far down your seeds need to go. She's going to give you all of that good information. So that when you get over here, you will be capable of planting a seed as long as you listen.

Likewise, Elizabeth described her lack of confidence and content knowledge during the follow-up interview, "I can barely keep a plant alive. I did okay with basil this summer. But now it's dead. Better luck next year." This perspective either introduces or perpetuates the notion to students that not just anyone can be an expert in growing plants.

The two teachers' confidence appeared to be higher when they could center their learning targets in disciplines other than science. For example, Melissa explained, "...they worked in teams to try to solve word problems that included the longest period between the important dates on the timeline." For literacy instruction, both Elizabeth and Melissa demonstrated confidence. Elizabeth explained that she,

Started the lesson by asking the students to write down everything they know about tomatoes. While the students took turns planting their tomato seeds I asked the remaining students to write down everything that they had learned about tomatoes along with any additional questions they still had about tomatoes.

Elizabeth appeared to be confident in how to sequence instruction that supports literacy. Similarly, Melissa, felt comfortable reinforcing literacy skills as she described how she integrated notebook writing: "The STEM notebooks were used over the course of the study so that students can write down their observations about their own plant's growth." Teachers used the EPC to reinforce a social studies standard centered on sequence of historical events, as Melissa explained to us, "First I asked the student to locate where they believed tomatoes originated. Then we read the tomato facts for the timeline, which included Thomas Jefferson serving tomatoes at his dinner, which coincides with the current social studies we are studying."

Finally, teachers were also able to use the EPC to address the national and state Comprehensive Health and Physical Education standards, as Elizabeth shared, "I read the book *I Will Never Not Ever Eat a Tomato* (Child, 2000) and led a discussion with good student participation about the health value of tomatoes and other vegetables." We did not identify instances when either teacher explained how the EPC allowed them to address science content standards about structure/ function of living organisms, abiotic/ biotic factors necessary for growth, or variations found in living organisms, both part of the state academic standards. Both STEM coordinators stated that they could see the value (to varying degrees) of integrating agriculture-based lessons into curricula but expressed concern that 3-5th grade elementary teachers would not see a direct connection to their respective state content standards in science, even though the

teachers acknowledged that plant science is an important component of STEM learning across grades.

Accessibility. Participants considered curricular resources to be accessible if they were 1) free/ affordable, 2) electronic/ downloadable, and 3) standards-based. Both teachers and STEM coordinator interviews described the lack of budget for purchasing lessons, so the school and departmental context contributes to teacher choices of curricula. Both teachers preferred lessons that are easily downloadable. They spoke positively about the EPC being available on a website along with all of the necessary student artifacts. Melissa explained that cost was important, “I will tend not to use a resource, if I have to pay for. If I can find a similar resource that is not as good but is free, I will choose the free resource and make it work.” Elizabeth agreed and stated, “Due to budget constraints we really can’t afford to pay for resources so we are always looking for free grade appropriate resources which are hard to find.” Susan concurred,

“I don’t have a curriculum to work with. I have to find resources on my own to work with and have to find a way to use the same material for each grade (K-5th), which is not always easy to find on the Internet. I have limited resources to work with and have to find a way to use the same material and modify it for each grade (K-5th) with little time to reset between classes.”

Melissa and Elizabeth chose lessons that they believed helped them meet their target standards and learning goals. Melissa explained that, “We are learning about Thomas Jefferson right now so the timeline ties in well with what we have been discussing.” Furthermore, both Melissa and Elizabeth chose lesson plans that they believed would engage their students to learn through: group work, self-directed learning, and hands-on inquiry activities. “The students worked as a team to determine whether the timeline was set up correctly,” Melissa explained when describing an EPC lesson she selected to implement. Elizabeth implemented a lesson activity requiring self-directed learning amongst students. Both teachers and Susan noted that hands-on activities prompted student questions and engaging in problem solving, especially during the tomato seed planting activity.

Relevancy. Both teachers made curricular selections based on relevancy to student lives. “None of our students are familiar with sweet potatoes or yams so we decided not to use those lessons,” Melissa shared. Elizabeth later explained that, “We felt as though the students couldn’t relate to those crops.” In follow up discussions with the two teachers it was apparent that they were unfamiliar with these two food crops and did not feel confident teaching about these.

Time. Both teachers felt strapped for time knowing that they must address several content standards during each week in order to meet state and district level expectations. They consistently described time as a factor when choosing lessons and that, “time is limited.” Elizabeth had intended to teach the Potato Unit but ran out of time. During post-intervention teacher interviews, she reflected on her time constraints, “When we went through [the curriculum], we gleaned it for time. There wasn’t a scientific reason for why we picked what we did. We simply said, ‘what do we have time to get through?’ which is pretty much what teaching is.” Observations of Melissa teaching revealed that much of the instructional time was spent trying to keep students focused on the content and learning objectives.

Instructional planning is time-consuming. Teachers made decisions that weighed more in favor of reading, writing, and mathematics standards, compared to STEM areas. Although at a STEM-centric elementary school, the teachers were still concerned about the state and district mandates for high performance outcomes on standardized tests. Susan explained, “I emphasize the process skills as opposed to the content that [teachers] are hopefully getting in the classes or alternately teach engineering and engineering design because they are not getting that content in class. The rest of the time is spent on reading, writing, and mathematics.” Susan, along with Melissa

and Elizabeth, discussed STEM topics as being separate from the other content areas even though lessons often integrated reading activities. Hence, science (and especially agricultural science) appeared to be an additional, not integrated, curricular goal. Susan, who at first expressed support for the EPC as being a standards-based curriculum, concurred with the teachers that it was “enrichment” and therefore, should be taught only if there was time.

Is agriculture STEM?

Neither Melissa nor Elizabeth thought that agricultural topics supported their STEM education objectives. Their perceptions of their own content knowledge and skills, as well as their confidence in teaching EPC lessons were informed by their perception that garden-based lessons are simply enrichment activities. Although both Melissa and Elizabeth were enthusiastic about the connection between the EPC and the school garden, they wanted an expert to visit their classroom to teach the lessons. As such, the EPC was considered to compete with instructional time for content that was assessed on the state standardized exam.

Melissa’s uncertainty about what constitutes agricultural literacy can be summed up when she was asked explicitly to define agricultural literacy and responded, “I’m not sure how to define this...stories with farming in it or just the ability and knowledge about plants/gardens?” Although the school is proud of their garden, the ways in which participants interpreted the term, “agriculture,” appeared to be limited to farmers or farming practices. In fact, neither teacher mentioned “agriculture” when teaching about potatoes or tomatoes.

Melissa, Elizabeth, and Susan thought that the EPC did not address science standards; rather it addressed food and health, even though Anna, the first STEM coordinator, believed it did. A 5th grade teacher indicated that elementary teachers might be literal readers of the academic standards and do not see plants as organisms that can be studied alongside vertebrate organisms. This particular teacher believed that plants are only food sources: “We are not focusing on plants this year. We are focused on the human body. So the only time we talk about food is when we discuss the human digestive system.” Again, teacher beliefs about what plants are and how they can be used to reinforce science concepts is likely limiting opportunities to use live organisms as models in biology lessons or to promote agricultural literacy.

Although the EPC supports state academic standards, teachers did not recognize the explicit connection to science. The third grade [state] life science standard states: “The duration and timing of life cycle events such as reproduction and longevity vary across organisms and species;” the fourth grade life science standard states: “All living things share similar characteristics, but they also have differences that can be described and classified;” the fifth grade standard states: “All organisms have structures and systems with separate functions.” Neither Melissa nor Elizabeth implemented EPC activities (such as planting tomato seeds or sprouting potatoes) that could have addressed the third grade state life science standard listed above. Informal interviews of the parent volunteer, who assisted during interventions and helped in the garden, confirmed the teachers’ hesitancy around any planting activities or germination studies. She explained that both of the teachers asked for parent volunteers to transplant seedlings because they did not want to touch the plants.

Discussion

In spite of many contextual factors that were intended to support teachers at one STEM-centric elementary school, the biggest barriers for two third grade teachers’ adoption of edible plant curricular resources were their own beliefs. Teachers not only believed that they could not grow plants, they did not believe that horticultural-based curricula address state science standards, even when these were explicitly cited on the lesson plans.

Teachers' Lack of Gardening Confidence

The teachers' confidence to teach about plants through inquiry-based lessons, as well as their beliefs that horticultural-based lessons did not meet state academic science standards emerged as the most important barriers for their independent adoption of the EPC. According to Knobloch (2008) elementary teachers are more likely to use agriculture literacy curriculum material if they fit into the grade-specific academic content that they are already using and meet the educational goals already established. These findings are informative to educators who recognize that agricultural topics relate to science, mathematics, social studies, and language arts. However, our study demonstrates that even when curriculum is clearly aligned to grade-specific content standards, the participants were still hesitant to implement the lessons. Teachers need help to overcome their lack of confidence by co-teaching or coaching on gardening activities. Moreover, support staff (e.g., STEM coordinators) need to think broadly about applied science.

Woodbury and Gess-Newsome (2002), in their model on school-based reform, stress structural/cultural contexts and personal contexts when evaluating reform efforts. They argue that contextual issues can help explain teaching beliefs, which, in turn may allow reformers to predict teacher practice. Interestingly, we found that the incentives to teach horticultural-based lessons were primarily *structural* and *cultural* and that the barriers were primarily *personal*. One might argue that two of the *structural/cultural* barriers (continued access to planting resources and connection of lessons to science standards) are really *personal* barriers because they are tied to the teachers' perceptions. If teachers do not cultivate partnerships with parent volunteers, they may not have resources to keep growing and studying plants. If the teachers do not know how to broadly interpret (personal barrier) the life science academic standards (in place because of structural contexts), they will perceive the EPC as competing for instructional time for other science content. The roles that the STEM coordinators played are important, especially in light of Southerland et al.'s (2007) explanation that the success or failure of reform efforts is often grounded in complex educational systems issues. If the teachers already had low self-efficacy regarding the teaching of plants, the reinforcement from a STEM coordinator (support teacher/ coach) that garden lessons are for enrichment and not primarily to meet academic standards, the teachers were able to justify not teaching the EPC on their own.

Teachers' Belief that Horticultural Lessons Are Not Science-Based

In spite of recent documents that explicitly describe the breadth of what science is, what scientific practices entail, and how science relates to engineering practices (NRC, 2012), there are still many elementary teachers who are uncertain about how to address science standards. Williams and Dixon (2013), in their thorough review of research of horticultural-based curricula posited that there is an opportunity for teachers to tie garden lessons with STEM disciplines. However, teachers in our study perceived horticultural-centered curricula as a means to support only their non-science standards. Others have also found that teachers have missed opportunities to support their teaching using agricultural contexts or themes (Eames-Sheavley, 1994; Warnick, Thompson, & Gunner, 2004). Skelly and Bradley (2000) evaluated elementary teachers' perceptions and use of school gardens and found that few teachers in their study integrated their garden to teach course content. Rather, the teachers used gardening activities to promote experiential and environmental learning. In our study, Susan held beliefs that mirror what Skelly and Bradley (2000) reported when she encouraged the belief that gardening was simply an enrichment activity. Even when teachers have participated in formal professional development on agricultural science, researchers have found that some teachers were not likely to implement these in their classrooms (Balschweid, Thompson, & Cole, 1998; Bellah & Dyer, 2009). After we shared our findings with the principal and STEM coordinator, the principal hired a school garden coordinator. Hence, our study was informative to this particular school community.

Several barriers will need to be overcome in order for teachers, STEM coordinators, and administrators to value edible plant science lessons as means to address both science (and potentially nutrition health) target learning goals. We did not identify any comprehensive professional development programs in the literature designed to promote the value of using edible plant science as a topic for inquiry-based learning across disciplines at the elementary school level. Our study pointed to the additional concern that not all science lessons are aligned with district assessment goals, and this adds another barrier or concern for elementary teachers (Keys & Kennedy, 1999). The EPC did address the teachers' desires to use inquiry-based lessons, consistent with Levitt's (2001) review of elementary teachers' perceptions of reform. Banilower, Heck, & Weiss (2007) found, in their review of professional development programs, that local issues and support from administrative and instructional support staff can predict successful reform efforts to integrate inquiry-based science curriculum. Not only is sustained professional development needed, instructional support staff (e.g., STEM coordinators) must participate in professional development along side of classroom teachers. Furthermore, elementary schools with school gardens may consider partnering with secondary schools in their district that have active agricultural education programs and educators who can act as mentors and instructional coaches.

Growing and preparing food for consumption is an everyday experience for millions of people across the globe. Furthermore, we believe that horticultural-based lessons allow elementary students to explore science concepts through engaging experiences, whether they have access to a school garden or not. We hope to conduct a follow up study at this school now that there is a school garden coordinator who has a science content background.

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