Journal of STEM Teacher Education

Volume 54 | Issue 1 Article 3

February 2020

Full STEAM Ahead: Creating Interdisciplinary Informal Learning Opportunities for Early Childhood Teacher Candidates

Sara L. Hartman
Ohio University - Main Campus, hartmans@ohio.edu

Danielle Dani
Ohio University - Main Campus, dani@ohio.edu

Journal of STEM Teacher Education
2019, Vol. 54, No. 1, 37-57

Full STEAM Ahead: Creating Interdisciplinary Informal Learning Opportunities for Early Childhood Teacher Candidates

Sara L. Hartman
Ohio University

Danielle Dani
Ohio University

ABSTRACT

Early childhood teacher candidates benefit when presented with opportunities to engage meaningfully with their clinically-based school community. Informal learning events that are hosted after school hours but within school settings present a valuable way to provide these opportunities. Too often, content areas exist in isolation in classrooms, a stark contrast to the real world where content is connected and overlapping. Additionally, while many early childhood teachers express insecurity about their ability to teach STEM content, an integrated STEAM (STEM + Arts & Humanities) approach may help to promote comfort with STEM content and presents an authentic example of content integration. This article presents a model of informal STEAM learning that capitalizes on collaborative school-university partnerships to improve both teacher candidate development and student learning outcomes. The model described provides practical ideas for facilitating successful informal STEAM events at local schools and is of value to a variety of educational stakeholders.

Keywords: Informal STEAM Learning; School-University Partnerships, Teacher Candidates, Professional Development School, Clinical Model of Teacher Preparation

In K-3 classroom settings, content areas too often exist in stark isolation from each other, yet, in the real world, science, math, literacy, social studies, and the arts are naturally connected in meaningful ways. Presenting content areas in an integrated STEAM (STEM + Arts & Humanities) manner provides children with authentic learning experiences and activities that are relevant to them (NSTA, 2009; Sharapan, 2012). Authentic learning activities allow children to develop understanding of ideas and relationships in real-world contexts; mimic the work of professionals; involve presentation of findings to audiences beyond the classroom; require exploration, inquiry, thinking skills and metacognition; and engage communities of learners in discourse and self-directed project work (Donovan, Bransford, & Pellegrino, 1999; Rule, 2006). Authentic learning experiences with real-world connections offer valuable learning opportunities for children in formal and informal contexts.

Despite the many benefits for children's learning that STEM and STEAM-based approaches offer, initiatives that implement them are more prevalent in middle and high schools across the United States (Bencze, 2008; Dejarnette, 2012). Proposed reasons for the slower rate of implementation in elementary schools include teachers' lack of pedagogical expertise and self-efficacy for scientific inquiry and technological design, which result from fewer opportunities to experience these in teacher preparation programs and the small amount of time dedicated to STEM teaching in the elementary classroom (Bencze, 2008; Ross, 1998; Smith & Southerland, 2007). In response to calls for better integration of these approaches into the elementary teacher education curriculum (Bencze, 2008; Dejarnette, 2012, Dani, Hartman, & Helfrich, 2018) reported the value of informal events as spaces for developing teacher candidates' pedagogical expertise and self-efficacy for teaching STEM disciplines. Situating STEAM learning within an informal learning event planned and implemented by early childhood teacher candidates who are completing elementary clinical experiences in grades K-3 can create meaningful learning opportunities for all involved. In this article, a rationale and two examples for using informal STEAM learning events in early childhood teacher education are described. Ideas for helping early childhood teacher candidates plan and implement informal learning events as part of their teacher preparation programs are also provided.

Background

The STEAM Approach

In response to the recent emphasis on STEM (Science, Technology, Engineering, & Math), early childhood educators are adopting a STEAM approach to integrate the arts and humanities into the early childhood curriculum (Chesloff, 2013). Although STEM educators have long emphasized the need for an integrated approach to STEM education (Bybee, 2010; Claymier, 2014; Dejarnette, 2012), a STEAM approach takes this a step further to promote integration beyond STEM disciplines. This approach is of particular relevance to early childhood educators because integrated and authentic learning is a hallmark of developmentally appropriate practice, and it allows children to see content areas as inter-connected (Ceschini, 2014; NSTA, 2009; Rich, 2010; Sharapan, 2012). From an instructional perspective, the goals of the STEAM approach are to purposefully present the content and practices of mathematics and science through the lens of technology, engineering, arts, and humanities; anchor the content in the design process; and situate learning within the present needs of students (Claymier, 2014; Gess, 2017).

Several conceptualizations of the integrated nature of STEAM teaching have been described, including transdisciplinary, interdisciplinary, multidisciplinary, and content and context (Herro, Quigley, & Dsouza, 2016; Moore et al., 2014). The transdisciplinary method uses the collective expertise of multiple disciplines to present and solve a problem and may incorporate all aspects of the STEAM acronym (Dyer, 2003; Henriksen, 2014). The interdisciplinary method draws from more than one discipline by emphasizing the similarities between the selected disciplines (Kim & Bolger, 2017). The multidisciplinary method to integration allows for the exploration of a common theme from the perspective of multiple disciplines (Kim & Bolger, 2017). In the context and content method of integration, a STEAM lesson emphasizes the content from one discipline and uses the context of another discipline to add relevance and facilitate the design or problem-solving process (Moore et al., 2014). Of importance, individual STEAM experiences or lessons may not incorporate all of the content areas represented by the STEAM acronym. For example, using the context and content method, teachers may emphasize a geometry concept using art and design principles. While the transdisciplinary approach to STEAM integration may be possible for larger problem-based projects that take place during the academic year, interdisciplinary and context-based approaches to integration between at least two disciplines are desirable for lessons and activities that span shorter periods of time (Moore et al., 2014).

Using STEAM in the early grades encourages learners to be creative, independent thinkers who are able to innovate and shift perspectives to discover new ways of viewing familiar things (Ceschini, 2014; Rich, 2010; Sharapan, 2012). It promotes students' ability to think divergently and problem-solve, both of which are key skills for the 21st century (Trilling & Fadel, 2009). When used in early elementary grades, the STEAM approach resulted in increases in students' achievement, motivation, and engagement in STEM learning, improving access to a wider audience of students (Becker & Park, 2011). For example, a STEM unit situated within the arts can scaffold meaningful learning for students with disabilities, creating connections that are missing from a STEM-only approach (Hwang & Taylor, 2016). STEAM-based learning can promote students' ability to transfer knowledge learned in school to out of school contexts (Fortus, Krajcik, Dershimer, Marx, & Mamlok-Naaman, 2005). It offers opportunities for teachers, students, families, and community members to collaboratively engage in a sustained investigation to solve a community-identified problem, such as building a tree house at the school (Weatherly, Oleson, & Kistner, 2017).

Perceptions and Challenges of the STEAM Approach

Despite the benefits of a STEAM approach, research finds that early childhood teachers and teacher candidates report challenges in implementing it. To start, elementary teachers and future teachers often express insecurities about their knowledge of and ability to teach STEM content (Bencze, 2008; Bursal & Paznokas, 2006; Murphy, Neil, & Beggs, 2007; Schneider et al.,2007). Building on Bandura's (1977) work on perceived self-efficacy and its impact on effort, persistence, and motivation to engage in particular tasks, several researchers have investigated elementary teachers' self-efficacy for teaching science (Riggs & Enochs, 1990), mathematics (Enochs, Smith, & Huinker, 2000; Tapia & Marsh, 2004), and engineering (Yoon Yoon, Evans, & Strobel, 2014). Findings of these studies consistently indicate that preservice and new elementary teachers exhibit low self-efficacy in their ability to teach STEM content areas (Bursal & Paznokas, 2006, Hammack & Ivey, 2017; Riegle-Crumb et al., 2015; van Aalderen-Smeets, Walma van der Molen, & Asma, 2012).

Other challenges for implementing the STEAM approach are based in elementary teachers' reports about the little time they spend teaching STEM content (Schneider et al., 2007). The isolated way they learned this content during their own educational experiences makes it difficult for them to identify natural connections between content areas. While some early childhood teachers do not view themselves as artists and share apprehension about teaching arts-based curricula (Battersby & Cave, 2014; Davies, 2010; Oreck, 2004; Russell-Bowie, 2012), others tend to feel increased confidence surrounding literacy, social studies, and art (Chesloff, 2013; Sharapan, 2012). Some express doubt that a STEAM approach can be used to achieve curricular and standards-based goals (Jamil, Linder, & Stegelin, 2017; Kim & Bolger, 2017).

Taken together, these challenges can impact early childhood and elementary teachers' ability to plan and engage students in authentic STEM and STEAM teaching. They highlight the need for providing teacher candidates with opportunities to engage in STEAM teaching to develop their self-efficacy for using the approach and support them to create STEAM-based lessons and experiences for children (Donahue & Stuart, 2008; Kim & Bolger, 2017; Zimmerman, 2016). A variety of programs and strategies have been used to increase early childhood teachers' STEM teaching self-efficacy (Deehan, Danaia, & McKinnon, 2017; Cone, 2009; Jarrett, 1999; Wingfield, Freeman, & Ramsey, 2000). For example, researchers Duran et al. (2009) found that interacting with an informal science organization increased inquiry-based science teaching self-efficacy. Early childhood teachers who participated in a one-day workshop focusing on STEAM found the STEAM approach valuable for their development (Jamil et al., 2017). Similarly, teacher candidates who created STEAM lesson plans developed positive attitudes toward the approach and self-efficacy for designing STEAM materials (Kim & Bolger, 2017). In short, developing and implementing STEAM curriculum in formal and informal settings supports teacher learning about the STEAM approach. In the next section, we describe the affordances of informal settings as places of learning for children, caregivers, and teacher candidates.

Impact of Informal Settings

Informal settings are places where learning occurs outside a formal classroom. These places can include museums, discovery centers, zoos and aquaria, clubs, libraries, online forums, and homes. Informal settings present a variety of content through displays, activities, and objects, cater to diverse learners of all ages, and invite voluntary attendance that results from intrinsic motivation (Bell et al., 2009; Koran, Koran, Foster, & Dierking, 1988; National Research Council, 2009). Not surprisingly, informal settings offer a learning environment that is beneficial to children's development. They allow children to actively construct meaning of new knowledge through hands-on, interdisciplinary, play-based, real-world, and authentic contexts (Bell et al., 2009; Brooks & Brookes, 1993; Gibbons, 2003; Migus, n.d.). Access to STEM and STEAM experiences in the early years contributes to children's increased interest in STEM disciplines (Bybee & Fuchs, 2006), yet access to these experiences is often limited for elementary aged children (Dejarnette, 2012; Hartman, Hines-Bergmeier, & Klein, 2017). As such, informal learning settings offer increased opportunities for children to engage in STEAM learning.

Informal settings also allow children and their caregivers to interact and learn together. Caregiver involvement in informal learning settings supports children's development (Olson & Drake, 2009), learning of STEM content (Bell et al., 2009), learning of history and art (Riedinger, 2012), and is essential to children's academic success (Buxton & Provenzo, 2011; Geerdts, Van de Walle, & LoBue, 2015; NSTA, 2009). Caregivers tend to direct children to notice physical characteristics of exhibits, help them comprehend information and instructions, and model appropriate ways for interacting with materials. Caregivers also ask children to make predictions about unobservable information, encourage scientific reasoning and causal inferences, elaborate on content by connecting it to past experiences and knowledge, and model interest for learning the content (Geerdts et al., 2015; Riedinger, 2012; Zimmerman, Reeve, & Bell, 2009).

Hosting events that offer developmentally appropriate informal learning experiences within a child's school but outside the formal classroom makes them more accessible to children and their caregivers (Bell et al., 2009; Bevan et al., 2010). The practice bridges formal (school-based) and informal learning, creating cross-contextual learning spaces (Fallik, Rosenfeld, & Eylon, 2013; National Research Council, 2009; Russell, Knutson, & Crowley, 2013). By attending a rich curricular event at a local school, caregivers may develop a better understanding of class content and may discover ways to make school content relatable to their children in out-of-school settings. Providing ways for caregivers to see the natural connections between school learning and out-of-school learning increases the chances that caregivers will seek additional informal learning opportunities for their children, many of which may support classroom learning topics (Bell et al., 2009).

Hosting informal events within school walls is also of value to the development of teacher candidates (Bottoms, Ciechanowski, Jones, de la Hoz, & Fonseca, 2016; Dani et al., 2018; Duran, Ballone-Duran, Haney, & Beltyukova, 2009; Harlow, 2012; Jamil et al., 2017). Informal learning events create service opportunities for teacher candidates to engage in meaningful ways with their clinically-based school communities, interact with caregivers and families from diverse racial, ethnic, and socioeconomic backgrounds, and provide a context for discussion of culturally relevant teaching practices in methods courses (Bell, Lewenstein, Shouse, & Feder, 2009; Bottoms et al., 2016; Dani et al., 2018; Harlow, 2012; Rennie, 2007). As communicating with caregivers and families is an area of heightened anxiety and low self-efficacy for new teachers (Hartman, Kennedy, & Brady, 2016; Melnick & Meister, 2008), creating opportunities for interactions with caregivers and families is important for teacher candidates' development.

Research also documents that informal learning events provide a way to increase early childhood teacher candidates' STEM knowledge and self-efficacy with STEM topics (Dani et al., 2018; Harlow, 2012). Applying what is known about the benefits of informal learning events and the importance of providing experience in implementing the STEAM approach in early childhood contexts, we used informal STEAM events to provide teacher candidates an opportunity to practice STEAM teaching. Informal STEAM learning events create an integrated twist to traditional STEM events. The practices presented in this article offer accessible ways to provide these opportunities for early childhood teacher candidates.

Context

The informal STEAM learning events described in this article occurred in the context of an Early Childhood Education program at Ohio University, a large university in the midwestern region of the United States. The program enrolls over 400 teacher candidates and provides licensure from age 3 to grade 3. Via Professional Development School (PDS) partnerships, the program utilizes a Clinical Model of teacher preparation (AACTE, 2018; NAPDS, 2008; NCATE, 2010). The PDS collaborative model creates unique partnerships between local PreK-12 schools and the university community that involve public school leaders and teachers, university faculty and administrators, and teacher candidates. Such partnerships create a rich community of learners that is able to positively influence both PreK-12 student learning and teacher candidate development (NAPDS, 2008).

The Clinical Model at Ohio University is focused on preparing teacher leaders through sustained clinical experiences with integrated co-teaching, extensive school-based mentoring, and a programmatic emphasis on advocacy and social justice (AACTE, 2018; NCATE, 2010). At the junior level, the early childhood program has PDS partnerships with six local elementary schools from three districts. Each PDS partnership has a university-based faculty coordinator and school-based teacher liaison who are an integral part of the junior year clinical experience. During their junior year, early childhood teacher candidates spend two full days each week in their PDS school. Teacher candidates are supported and supervised by mentor teachers, the school's teacher liaison, and the university's faculty coordinator, both in classrooms and through a weekly seminar held at their elementary school. In their PDS cohort group, early childhood candidates also take coursework (content, pedagogy, and content-specific pedagogy) on the university campus.

The sustained nature of the early childhood PDS partnerships has allowed for the incubation of innovative ideas to further promote student learning. One of these ideas involved helping candidates plan and host STEAM-focused informal learning events at their PDS partnership schools. Nearly all PDS partnership schools host informal learning events one to two times per year that are planned by teacher candidates. Each semester, if a school does not host its own event, the teacher candidates placed at that school are required to assist at informal learning events happening at other PDS sites. In this way, all early childhood teacher candidates at Ohio University gain experience in hosting informal learning events. The events allow candidates to interact with their students and students' caregivers in out-of-school events that promote family engagement and cross-contextual learning. The events also support candidates' development as early childhood teachers by providing them with authentic opportunities to present interdisciplinary content. As the STEAM events grew from idea to reality, teacher candidates also pursued partnerships with community entities, including public libraries, museums, environmental agencies, and local businesses. The collaboration among these multiple stakeholders, together with the existing collaborative school-university partnerships, contributed to the success of the two STEAM events described in this article.

The STEAM Events

To illustrate the types of integrated events that early childhood teacher candidates are capable of planning and hosting, two STEAM events are described. The first, *World Market*[1], combined Social Studies and Math content, and the second, *Reading & Science Night*, integrated literacy, science, and art content. For each informal STEAM event, teacher candidates created both an interactive, hands-on activity and a content focused poster. The posters provided background knowledge about the STEAM content of the activity, directions for participating in the activity, and learning standards for each content area (Figure 1).

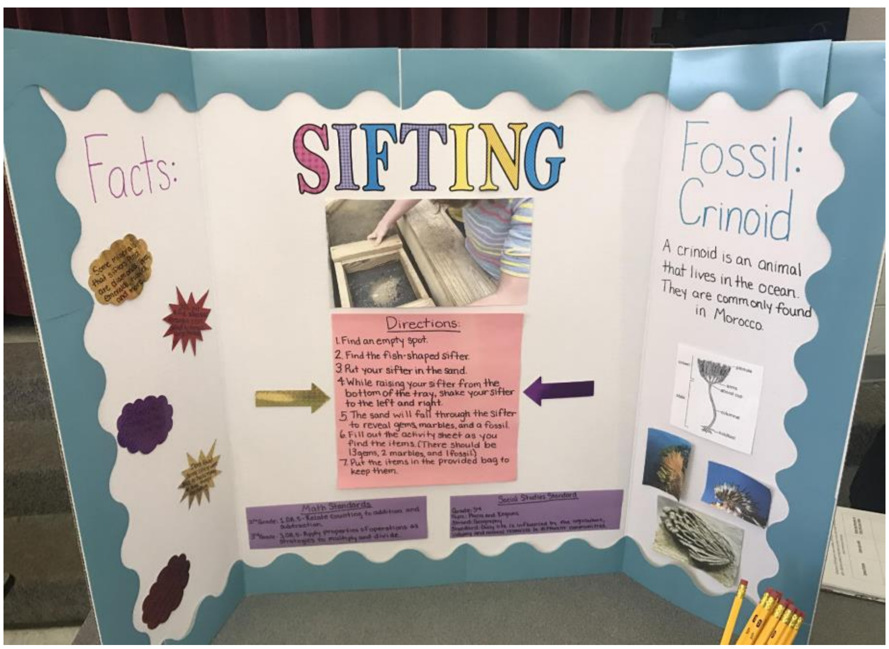

Figure 1. An example of an accompanying STEAM poster.

[1] Pseudonyms are used for event names.

Both events were conducted at one PDS school where early childhood candidates were completing their junior year clinical placement. Between 18 and 21 ECE partnership teacher candidates facilitated the STEAM stations at each event. The school is classified as a high poverty, rural school with approximately 400 children attending in grades K-6. Over 125 children, ages kindergarten-sixth grade, their siblings, and families/caregivers attended each of the events. As the school typically struggles to attract student attendance and parent/caregiver engagement at after-school events, this is a very large attendance number. During each event, caregivers were encouraged to actively participate in the stations with their child. Additional participants included teachers, administrators, and university faculty. Following each event, teacher candidates reflected on their experiences. In the remainder of this paper, we use quotes from these reflections to provide more context and a better feel for the type of learning environments generated by these events.

World Market

World Market was inspired by a desire to make family nights at the candidates' school more interdisciplinary and to create natural connections to teacher candidates' methods courses. Each fall semester, candidates take math and social studies methods courses, so it was important to see both of these content areas reflected in the informal learning event's content. Art provided another natural connection to each content area. The faculty coordinator at the teacher candidates' school, who was also their social studies methods instructor, first proposed the idea of integrating the two content areas for the informal event. *World Market* was the first event in Ohio University's PDS network to be developed specifically to have an interdisciplinary, STEAM focus. Previously, all informal events were solely STEM focused. At first, early childhood candidates were nervous about finding a connection between the STEAM content areas and expressed trepidation about stations that made this connection. However, with modeling, many examples, and support from their teacher liaison, math methods instructor, and mentor teachers, teacher candidates began to develop ideas for their interactive stations and began to see the natural, real-word connections between math and social studies (see Table 1 for examples of the math/social studies stations). For example, a teacher candidate developed the Peruvian "Pan" Flutes station, which used concepts from social studies (geography), mathematics (measurement), and music (instruments) to *design*, create, and learn about pan flutes. The name of the event emerged as ideas began to take shape and excitement about the event was building. *World Market* was very well attended and was met by extremely enthusiastic reviews (Figure 2). Children also carried a "passport" around and received stamps as they visited each station. Reflects a teacher candidate, "I think *World Market* went really well. I was not sure what to expect, so I was very nervous. I was really engaged the whole night, and I think it was great for kids to see the connection between math and social studies." Based on the reactions of children, families, and teacher candidates, the teacher liaison and faculty coordinator decided to embrace a STEAM approach for the spring informal event, too. This is described next.

Reading & Science Night

As science content methods courses are sometimes challenging for teacher candidates, for *Reading & Science Night*, teacher candidates were asked to start the planning for their station by identifying a picture book that inspired a science connection through art or literacy. As part of their weekly seminar class, the faculty coordinator and teacher liaison also set up four examples of stations that modeled science, reading, and art connections. One example involved using the wordless picture book, *Journey* (Becker, 2013), as a launching point for a discussion of how art can tell a story without words and for creating science connections to buoyancy and floating. Creating aluminum foil boats with the goal of carrying as many pennies as possible (i.e. penny boats) was presented as the station's activity.

Table 1.
Market Around the World Stations

Station Name	Description
Farmer's Market	This station allowed children to purchase fruits or vegetables for a healthy snack. Upon arriving, each child was given $2.00 in play money to use to purchase fruit and vegetables at the "Farmer's Market."
Kongki Noli	A traditional Korean math game that uses stones and is similar to "jacks." After tossing and catching their stones, children and caregivers added their scores after each round of play.
Terrific Timelines	Each visitor to the event had the opportunity to add an important event to the school timeline. After that, they could use an array of art materials to create their own timeline. Children and caregivers chose to work individually or together to create their timelines.
Tangrams	The ancient Chinese puzzles became life-size floor puzzles. Children and caregivers worked together to arrange the pieces to match templates or create their own seven-piece puzzle.
Peruvian "Pan" Flutes	First, visitors found Peru on a map. Second, they learned about Pan, the Greek god of nature who was often depicted holding a flute. Third, children and caregivers measured and cut straws to make their own pan flutes, which originated in Peru. Finally, visitors created music with their pan flute.
Jobs in Our Community	Children and caregivers chose a job and then collectively created tally marks and a bar graph with their chosen professions.
Life-Sized Shisima	This math game from Kenya allowed up to six players at a time to become life-sized game pieces. A game of strategy, Shisima invited children and caregivers to use collaboration and advanced planning to assemble three people in a line to win the game.

From there, teacher candidates began bringing picture books to school to share with each other and began developing their own science activity that connected to their book (see Table 2 for examples of picture books with science station connections). Candidates were encouraged to choose books from a variety of genres and to not limit themselves to nonfiction science-focused books. In total, teacher candidates created 21 science stations for the event, which was attended by over 100 children and their caregivers. To illustrate, visitors to the *Rosie the Raven* (Bansch, 2015) station were encouraged to read the book (literacy) and use key details to the life cycle, basic needs, and adaptations of ravens (literacy and science) to *design* and create an aesthetically pleasing raven bird feeder (science and visual arts). Each picture book was displayed with the station's activity and was available for reading during the event (Figure 3). Teacher candidates also invited local organizations to partner in the event. The small town's public library set up a reading station, and two science-focused and one STEAM focused organization also created stations for the event. Even though teacher candidates had an extremely busy semester, all felt the informal event was worthwhile and appreciated the real-word model that the STEAM approach created. Illustrating this, one teacher candidate says, "One of my big take-aways was just seeing how much fun everyone was having. There were so many integrated stations, and everyone who came to the event and worked the event seemed to have an awesome time while learning." The following section presents facilitating factors that may be useful to other stakeholders who wish to plan and host a STEAM event with their early childhood teacher candidates.

Table 2.
Reading & Science Night Picture Books and Activities

Picture Book*	Activity Description
Diary of a Worm By Doreen Cronin Illustrated by Harry Bliss	This station allowed children and caregivers to get up close and personal with worms. They were encouraged to identify the different parts of worms' bodies, as well as discuss their diets and habitats.
Rosie the Raven Written and Illustrated by Helga Bansch	Children and caregivers worked together to make homemade birdfeeders that they could hang in their yard or community. Sun butter was made available for visitors with nut allergies.
Dannie and the Monarch Butterfly Written and Illustrated by Helga Bansch	All four cycles of butterfly development were explored at this interactive station. Visitors created representations of all four cycles that they could take home with them.
The Man Who Walked Between the Towers Written and Illustrated by Mordicai Gerstein	Using straight and/or bendy straws and playdoh, children and caregivers worked together to create and build their own tower.
One Plastic Bag: Isatou Ceesay and the Recycling Women of Gambia By Miranda Paul Illustrated by Elizabeth Zunon	Children and caregivers upcycled plastic grocery bags by weaving them into jump ropes. Then, they could practice jumping rope with their creations.
The Turnip Written & Illustrated by Jan Brett	With many real life examples, children and caregivers examined and drew the parts of a plant.

*Each book was available at the corresponding station. Caregivers and children were encouraged to read them together.

Figure 2. Graphing and communities creates a math/social studies connection.

Figure 3. A book about worms encourages worm exploration at the station.

Facilitating a STEAM Event

Content Connections and Idea Formation

Methods Courses. Each STEAM event was designed to complement the content methods courses that teacher candidates were taking in the corresponding semester. As such, math and social studies were grouped, as were literacy and science. The arts, which are infused throughout much of early childhood classroom activities, provided a natural companion to both events. Creating clear content connections to the methods courses teacher candidates are currently taking is highly recommended. A teacher candidate emphasizes this saying, "It was helpful to us to have the content match our methods courses. It gives us an opportunity to see how they are related." This also creates natural connections between teacher candidates' university coursework and their clinical placements.

During weekly seminars, the faculty coordinator and teacher liaison introduced STEAM pedagogy and offered considerable support to candidates as they developed their ideas and allowed time to discuss ideas and test activities with each other. During the content-specific methods courses, university faculty discussed readings about hosting informal events. For example, science educators facilitated discussions around articles from publications of the National Science Teachers Association (e.g., McCubbins, Thomas, & Vetere, 2014; Sutton & Hatton, 2011). Teacher candidates received feedback on their initial ideas and activity summaries from the faculty coordinator and teacher liaison. To best facilitate this process, frequent communication and dedicated class time to develop ideas is essential.

Station Requirements. Each station that teacher candidates designed had to: 1) Be interdisciplinary with a real-world connection; 2) Be interactive and hands-on; and, 3) Foster collaboration between children and caregivers. Integrating grade appropriate standards with each content area was also expected, and standards for content areas were displayed on each station's accompanying poster. For each station, teacher candidates connected the activity to students' prior knowledge, whether it was something they learned in school or an activity they participated in on a field trip, or something that related to what was happening in their life outside of school in their family or the community. For example, one station at *World Market* was focused on a Farmer's Market and connecting it to the local farmer's market was important. Making authentic connections to children's communities made the stations more relevant to young learners. For *Reading & Science Night*, teacher candidates spent time reading the accompanying picture books to the students in their classrooms. Creating these requirements for stations is recommended for those who develop their own informal STEAM events.

Planning and Preparation

Committees. Teacher candidates took the lead on planning all the logistical details associated with each STEAM event. They formed committees for advertising, fundraising, refreshments, materials and supplies, volunteers and many others. For example, the budget committee was responsible for making sure the costs associated with each committee fit within the allotted budget for each informal event. Table 3 lists the types of committees and a description of their duties. Teacher candidates also coordinated with community agencies, school personnel, and PTOs throughout the planning process. Adopting a committee system is recommended to ensure all candidates are responsible for planning some part of the informal event's logistics and for making sure the workload is evenly distributed. As a teacher candidate describes, "It helps to have the work spread out. That way no one is responsible for too much, and we can also focus on our stations."

Table 3.
Committee Types and Assignments

Committee Title	Description of Duties
Volunteers	The volunteer committee recruits, schedules, and supervises volunteers during the event.
PTO Communications	This committee communicates with the PTO to arrange possible collaborations for refreshments and school-wide notifications (e.g. School newsletter).
Advertising	This committee notifies local media outlets and communicates event information to important stakeholders, such as the superintendent and school board.
Theme/Decorating	Creating a festive atmosphere is important to the overall look of the event. This committee is responsible for designing and implementing the event's theme.
Family/Caregiver Notifications	Teacher candidates in this committee wrote paper notifications and emails to notify families about the upcoming informal STEAM events.
Fundraising	Members of this committee contacted local business to solicit both monetary and in-kind donations of supplies and/or equipment.
Supplies	Each teacher candidate communicated their supply needs to the members of this committee. Once supply lists were received, committee members organized the lists and searched for affordable vendors to purchase needed supplies.

Materials and Equipment. Implementing each event required teacher candidates to acquire materials and equipment. Some supplies were consumable and had to be purchased in advance of the event (e.g. glue, dirt, paper plates, beads, stickers, straws, cornstarch, … etc.) To raise money for these supplies the following funding sources are recommended, 1) The school's Parent-Teacher Organization; 2) Local businesses (e.g. a local grocery store donated fresh produce and bottled water); and, 3) Small university-based grants. Some supplies and equipment were borrowed from the candidates' mentor teachers (e.g. markers, scissors, and stamps), while others were borrowed from university faculty and university laboratories (e.g. black light for the Germ Station). A week before each event, the faculty coordinator took candidates who needed consumable materials shopping at local stores. The teacher candidates picked out the materials they needed, the faculty coordinator paid for them, and then the candidates took the supplies with them. In that way, candidates were responsible for preparing and stocking their own station. It should be noted that a large budget is not needed to facilitate an effective STEAM learning event. The events described in this article were each implemented for around $150.

Volunteers. Each STEAM event was supported by volunteers who served as material managers at some stations, monitored attendance and sign-in, and helped with cleanup. Volunteer support during the events was essential to helping the events run smoothly. Having volunteers available to help staff stations provided additional help for messy stations (e.g. Oobleck) or those that were creating intricate products (e.g. life cycle of a butterfly). Teacher candidates should utilize their networks to attract volunteers to their informal events. For the STEAM events described here, volunteers included teacher candidates from other early childhood PDS partnership schools, student organizations, and from other majors. Reflects a teacher candidate, "I am very grateful that candidates came from other schools, because it gave us extra help at our stations. If I hadn't had help, I wouldn't have been able to get kids in and out of my station efficiently." Facilitating events of this nature requires some degree of volunteer recruitment and engagement and should be planned for early as the STEAM event is developing.

Advertising. To ensure attendance at the STEAM events, the planners should consider an advertising strategy. At the events described here, teacher candidates were innovative in their advertising plans. The events were advertised in the school newsletter, in the morning announcements, by stapling reminder bracelets on each child on the day of the events, in a promotional video that was shown in each classroom, and via signs posted around the school (Figure 4). Before *Reading & Science Night*, teacher candidates also read the accompanying picture books to their classes. In this manner, they generated a lot of enthusiasm and excitement about the events. Advertising may also be done with the help of the PTO. Teacher candidates should work together to advertise in a way that best suits the needs of their school, whether it be in print form, such as a printed flyer, or through an electronic message on the school's website, email, or social network sites.

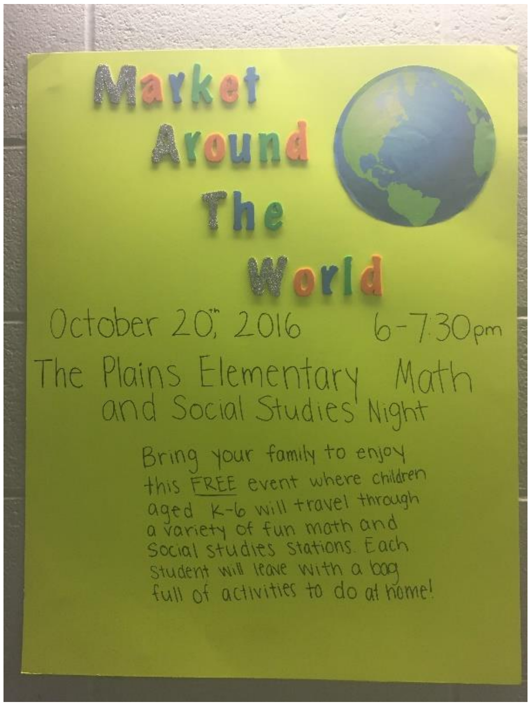

Figure 4. Posters advertising the events were displayed around the school.

During the Event

Active Engagement. Each of the STEAM events lasted for one and a half hours, and active engagement from teacher candidates was expected the whole time. Maintaining focus and enthusiasm during informal learning events is essential (Dani et al., 2018). This presented a unique opportunity for teacher candidates to interact with children and families in a non-threatening and fun manner. Speaking of her station about moon phases, a teacher candidate shares:

> I tried to be open, positive, and engaged. I think being open and positive is important for creating a safe space and feeling comfortable. Being engaged in your station and being able to discuss the different moon phases with your students is important so they aren't only having fun but learning something as well.

Teacher candidates were encouraged to come out from behind their station's table, to greet each visitor enthusiastically, to help children use the manipulatives and supplies, and to ask inquiry driven questions. Teacher candidates got on the floor to help children count with manipulatives, helped them measure and pour ingredients, and interacted with families throughout each of the events. This type of engaged behavior was necessary for truly inclusive events and aided greatly in their success.

In order to help teacher candidates be ready for the event, it is recommended that the events be held in the early evening. The STEAM events described here were held from 5:30-7:00, which allowed teacher candidates to set up after school at a leisurely pace. Making sure candidates know the importance of active engagement before the event begins is of paramount importance. During the event, it is helpful if university and school-based instructors are present and encouraging teacher candidates to be actively participating with the children and caregivers at their station. Teacher candidates may need to be reminded to ask children and caregivers to join them at their station and to present a welcoming and approachable demeanor. Creating an expectation of active engagement helps greatly in facilitating a successful event.

Encouraging Caregiver Involvement. Child/caregiver collaboration at an informal event can also lead to continued learning in the home (Bell et al., 2009; Olson & Drake, 2009). One challenge for schools and informal learning providers is bridging the gap between school learning and out-of-school learning (Voss, 2011). Stations that encourage collaboration between children and their families/caregivers create important opportunities for in-school learning to continue outside the school walls. As such, teacher candidates should be prepared to encourage children and caregivers to engage together in the station's activities. Sometimes, this requires a teacher candidate to gently encourage a caregiver/parent to get involved by asking a question or welcoming them to the event. It also requires teacher candidates to plan activities that provide accessible and fun ways for caregivers to participate in the station (Figure 5). While this does not always result in a caregiver getting involved, it does frequently result in more active caregiver engagement. Reflecting on the value of caregiver involvement during the STEAM events, a teacher candidate expressed:

I believe it is so vital to interact with families in this type of setting. Although you see families during conferences, it can be a totally different situation because you may have to touch on some difficult topics when meeting. To be able to interact with them in a fun and carefree area, allows me as a teacher candidate to get to know who the parents are and what they want for their child.

Figure 5. Shisima, an interactive math game from Kenya, got everyone engaged.

After the STEAM Event

Facilitating an informal STEAM event should also involve documenting and reflecting on the event. For the STEAM events described here, teacher candidates reflected on their experiences via discussions during seminar and through written reflections. Additionally, both the faculty coordinator and the teacher liaison sought feedback from the school's mentor teachers and principal. As ascertained via these discussions, the school's principal recommended that all future informal events adopt an interdisciplinary STEAM focus. As a result, a future informal event also incorporated Physical Education content. Teacher candidates may also want to contact a local newspaper so that pictures and/or a story about the event can be featured within the community. Finally, encouraging teacher candidates to share the success of the event to the school's school board and superintendent provides a very valuable opportunity for candidates to both celebrate their success and gain a better understanding of the organization of a school system. If a group of candidates uses a committee structure as described here, dissemination can be a committee assignment.

Final Thoughts

The success of the STEAM events was predicated on a strong collaborative and community-based approach to planning. Using this STEAM model, collaborations can be sought, nurtured, and leveraged to advance the real-world, authentic learning of children using similar events. In the model presented here, the time and space afforded by the early childhood PDS partnership was utilized to engage teacher candidates in the design and development of the events. The process requires a time commitment from both school and university-based partners and will work best in contexts where teacher candidates have the time and space to engage in similar processes (e.g., dedicated course time, student professional organization activity, or service learning project). Collaboration between school, university, and community participants was paramount in the delivery of each STEAM event. If adopted as part of clinically-based teacher education programs, this model can lead to an institutionalized, cyclical approach to interdisciplinary informal learning events within school settings. When implemented twice a year, the success of each informal event then carries forward to the next event.

Teacher candidates who facilitate informal STEAM events can benefit in many ways. Prior research indicates that informal STEM events provide clinical opportunities for teacher candidates to teach science in authentic settings, interact with children and their caregivers, and gain much needed confidence about STEM content (Dani et al., 2018; Harlow, 2012). Informal STEAM events can provide teacher candidates with similar opportunities to gain confidence about STEM/STEAM content. However, utilizing a STEAM approach, as opposed to a STEM focus, creates more real-world, integrated experiences. Describing her penny boat design station, a candidate reports:

> One thing that I learned about my experiment was that objects stay afloat when they have a greater ratio of empty space to mass than fluid. I thought this was beneficial for me as a future teacher, because I was able to better explain density and mass to the students who came to my station, which impacted the artistic design process of their boats.

Whereas a STEM approach may further the impression that STEM content exists in isolation from the arts and humanities, a STEAM approach models real-world integration of content areas (NSTA, 2009; Sharapan, 2012).

Teacher candidates' involvement in STEAM events can also contribute to their development as leader educators who will be able to design and implement community-engaging events at their schools. Emphasizing this, a teacher candidate states, "The STEAM nights made me see how I want to work in a school setting very similar to my partnership school and to be able to collaborate with future coworkers to make fun family nights." Such involvement provides much needed real-world experience about their role as a teacher outside of the formal classroom and allows them to witness the importance of a community coming together to promote student learning. As testament to this, a teacher candidate relays, "For me, the most beneficial part of these events is seeing the school community come together to create an amazing night for students and families." Facilitating informal STEAM events promotes teacher candidates' learning about the many logistical details that are needed to make informal learning events a success and the value of investing their time to engage with their school community.

While informal conversations with all stakeholders involved in the STEAM events described in this article support our belief that these events are impactful, formal research to investigate the benefits of STEAM events is needed. Future research should focus on the impact of facilitating STEAM events on teacher candidate development and self-efficacy. Future research should also investigate the benefits of informal STEAM events to children and caregivers. Informal STEAM events that are located within school settings create meaningful opportunities to bring together university, school, and community stakeholders in ways that enhance children's knowledge. Informal STEAM events provide important ways to bridge the learning that happens within formal school classrooms and the interdisciplinary learning that happens during out-of-school hours. Stakeholders in other locales may take the practices presented in this article to plan and implement their own successful informal STEAM events.

References

American Association of Colleges for Teacher Education Clinical Practice Commission (AACTE). (2018). *A pivot toward clinical practice, its lexicon, and the renewal of educator preparation*. Washington, D.C.: AACTE. Retrieved from https://aacte.org/professional-development-and-events/clinical-practice-commission-press-conference

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

Bansch, H. (2015). *Rosie the raven*. Toronto, Canada: Annick Press.

Battersby, S. L., & Cave, A. (2014). Preservice classroom teachers' preconceived attitudes, confidence, beliefs, and self-efficacy toward integrating music in the elementary curriculum. Update: Applications of Research in Music Education, 1-8. doi: 8755123314521033

Becker, A. (2013). *Journey*. Somerville, MA: Candlewick Press.

Becker, K., & Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis. *Journal of STEM Education*, *12*, 23-37. doi: 10.12691/education-2-10-4

Bell, P., Lewenstein, B. V., Shouse, A. W., & Feder, M. A. (2009). *Learning science in informal environments: People, places, and pursuits*. Washington, DC: National Academies Press.

Bencze, J. L. (2008). Promoting student-led science and technology projects in elementary teacher education: Entry into core pedagogical practices through technological design. *International Journal of Technology and Design Education, 20*, 43-62. doi: https://doi.org/10.1007/s10798-008-9063-7

Bevan, B., Dillon, J., Hein, G.E., Macdonald, M., Michalchik, V., Miller, D., et al. (2010). *Making science matter: Collaborations between informal science education organizations and schools*. Washington, DC: Center for the Advancement of Informal School Science Education (CAISE). Retrieved from http://www.informalscience.org/documents/MakingScienceMatter.pdf

Bottoms, S.I., Ciechanowski, K., Jones, K., de la Hoz, J., & Fonseca, A.L. (2016). Leveraging the community context of family math and science nights to develop culturally relevant teaching practices. *Teaching and Teacher Education*, *61*, 1-15. doi: http://dx.doi.org/10.1016/j.tate.2016.09.006

Brooks, J., & Brookes, M. (1993). *In search of understanding: The case for constructivist classrooms.* Alexandria, VA: Association for Supervision and Curriculum Development.

Bursal, M. & Paznokas, L. (2006). Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science, *School Science and Mathematics*, *106*, 173-180. doi: https://doi.org/10.1111/j.1949-8594.2006.tb18073.x

Buxton, C. A., & Provenzo, E. F. (2011). *Teaching science in elementary and middle school: A cognitive and cultural approach* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Bybee, R. W., & Fuchs, B. (2006). Preparing the 21st century workforce: A new reform in science and technology education. *Journal of Research in Science Teaching, 43*, 349-352. doi: https://doi.org/10.1002/tea.20147

Bybee, R.W. (2010). Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher, 70*, 30-35. Retrieved from https://eric.ed.gov/?id=EJ898909

Ceschini, J. (2014). STEM + art: A fruitful combination. *Education Week, 34*, 22–23.

Chesloff, J. D. (2013). STEM Education must start in early childhood. *Education Week, 32*, 27–32. Retrieved from http://maroundtable.com/doc_news/1303_EdWeek_STEMEarlyChildhood.pdf

Claymier, B. (2014). Teaching 21st century skills through an integrated STEM approach. *Children's Technology & Engineering, 18*, 5. Retrieved from http://content.ebscohost.com/

Cone, N. (2009). Preservice elementary teachers' self-efficacy beliefs about equitable science teaching: Does service learning make a difference? *Journal of Elementary Science Education, 21*, 25-34. doi: https://doi.org/10.1007/BF03173682

Dani, D., Hartman, S.L., & Helfrich, S. (2018). Learning to teach science: Elementary teacher candidates facilitate informal STEM events. *The New Educator*, *14*, 363-380. doi: 10.1080/1547688X.2017.1356413

Davies, D. (2010). Enhancing the role of the arts in primary pre-service teacher education. *Teaching and Teacher Education, 26*, 630-638. doi: 10.1016/j.tate.2009.09.011

Deehan, J., Danaia, L., & McKinnon, D.H. (2017). A longitudinal investigation of the science teaching efficacy beliefs and science experiences of a cohort of preservice elementary teachers. *Journal of Elementary Science Education, 39*, 2548-2573. doi: https://doi.org/10.1080/09500693.2017.1393706

DeJarnette, N. K. (2012). America's Children: Providing Early Exposure to STEM (Science, Technology, Engineering and Math) Initiatives. *Education, 133*, 77-84. Retrieved from https://www.researchgate.net/profile/Nancy_Dejarnette/publication/281065932_America's_Children_Providing_early_exposure_to_STEM_Science_Technology_Engineering_Math_Initiatives/links/56e8a01208ae166360e52647.pdf

Donahue, D., & Stuart, J. (2008). Working towards balance: Arts integration in preservice teacher in an era of standardization. *Teaching and Teacher Education*, *24*, 343-355. doi: https://doi.org/10.1016/j.tate.2006.11.016

Donovan, S., Bransford, J., & Pellegrino. (1999). *How people learn: Bridging research and practice.* Washington, DC: National Academy of Sciences.

Duran, E., Ballone-Duran, L., Haney, J., & Beltyukova, S. (2009). The impact of a professional development program integrating informal science education on early childhood teachers' self-efficacy and beliefs about inquiry-based science teaching. *Journal of Elementary Science Education*, *21*, 53-70. Retrieved from http://files.eric.ed.gov/fulltext/EJ867290.pdf

Dyer, J. A. (2003). Multidisciplinary, interdisciplinary, and transdisciplinary educational models and nursing education. *Nursing Education Perspectives*, *24*, 186-188. Retrieved from https://search.proquest.com/docview/230625184/fulltextPDF/8993398DA3E34F30PQ/1?accountid=12954

Enochs, L. G., Smith, P. L., & Huinker, D. (2000). Establishing factorial validity of the Mathematics Teaching Efficacy Beliefs Instrument. *School Science and Mathematics*, *100*, 194-202. doi: https://doi.org/10.1111/j.1949-8594.2000.tb17256.x

Fallik, O., Rosenfeld, S., & Eylon, B-S. (2013). School and out-of-school science: A model for bridging the gap. *Studies in Science Education. 49*, 69-91. doi: 10.1080/03057267.2013.822166

Fortus, D., Krajcik, J., Dershimer, R. C., Marx, R. W., & Mamlok-Naaman, R. (2005). Design based science and real-world problem-solving. *International Journal of Science Education, 27*, 855-879. doi: https://doi.org/10.1080/09500690500038165

Geerdts, M.S., Van de Walle, G.A., & LoBue, V. (2015). Parent – child conversations about animals in informal learning environments. *Visitor Studies, 18*, 39-63. doi: https://doi.org/10.1080/10645578.2015.1016366

Gess, A. H. (2017). Steam education: Separating fact from fiction. *Technology and Engineering Teacher, 77*, 39-41. Retrieved from https://search.proquest.com/docview/1962558419/fulltextPDF/207B82E910134AAFPQ/1?accountid=12954

Gibbons, B. (2003). Supporting elementary science education for English Learners: A Constructivist Evaluation Instrument. *Journal of Educational Research, 96*, 371-380. doi: 10.1080/00220670309596620

Hammack, R. & Ivey, T. (2017). Examining elementary teachers' engineering self-efficacy and engineering teacher efficacy. *School Science and Mathematics, 117*, 52-62. doi: https://doi.org/10.1111/ssm.12205

Harlow, D. B. (2012). The excitement and wonder of teaching science: What pre-service teachers learn from facilitating family science night centers? *Journal of Science Teacher Education, 23*, 199-220. doi: 10.1007/s10972-012-9264-5

Hartman, S.L., Hines-Bergmeier, J., & Klein, R. (2017). Informal STEM learning: The state of research, access, and equity in rural early childhood settings. *Journal of Science Education and Civic Engagement, 9,* 32-39. Retrieved from http://new.seceij.net/wp-content/uploads/2017/07/Hartman.pdf

Hartman, S., Kennedy, C., & Brady, B. (2016). Graduate teaching fellowships as new teacher induction: School-university partnerships' impact on teaching self-efficacy. *School-University Partnerships, 9,* 171-187. Retrieved from http://napds.org/wp-content/uploads/2016/10/93-hartman.pdf

Henriksen, D. (2014). Full STEAM ahead: Creativity in excellent STEM teaching practices. *The STEAM Journal*, *1*, 15. doi: 10.5642/steam.20140102.15

Herro, D., Quigley, C., & Dsouza, N. (2016). STEAM enacted: A case study exploring middle school teachers implementing STEAM instructional practices. *Journal of Computers in Mathematics and Science Teaching, 35,* 319-342. doi: 10.1080/19415257.2016.1205507

Hwang, J., & Taylor, J. C. (2016). Stemming on STEM: A STEM Education Framework for Students with Disabilities. *Journal of Science Education for Students with Disabilities*, *19,* 39-49. Retrieved from http://scholarworks.rit.edu/cgi/viewcontent.cgi?article=1052&context=jsesd

Jamil, F. M., Linder, S. M., & Stegelin, D. A. (2017, online first). Early childhood teacher beliefs about STEAM education after a professional development conference. *Early Childhood Education Journal,* 1-9. doi: 10.3102/0013189X025009006

Jarrett, O. S. (1999). Science interest and confidence among preservice elementary teachers. *Journal of Elementary Science Education*, *11*, 49–59. doi: https://doi.org/10.1007/BF03173790

Kim, D., & Bolger, M. (2017). Analysis of Korean elementary pre-service teachers' changing attitudes about integrated STEAM pedagogy through developing lesson plans. *International Journal of Science and Mathematics Education, 15*, 587-605. doi: 10.1007/s10763-015-9709-3

Koran, J.J., Koran, M.L., Foster, J.S., & Dierking, L.D. (1988). Using modeling to direct attention. *Curator*, *31,* 36-42. doi: https://doi.org/10.1111/j.2151-6952.1988.tb00673.x

McCubbins, S., Thomas, B., & Vetere, M. (2014). Family science day: A family science event engages a community in STEAM exploration. *Science and Children, 51*, 44-47. Retrieved from https://www.ebscohost.com

Melnick, S. A., & Meister, D. G. (2008). A comparison of beginning and experienced teachers' concerns. *Educational Research Quarterly*, *31,* 39-56. Retrieved from http://files.eric.ed.gov/fulltext/EJ788428.pdf

Migus, L. H. (n.d.). Broadening access to STEM out-of-school learning environments. The National Academies. Retrieved from http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_089995.pdf

Moore, T. J., Stohlmann, M. S., Wang, H. H., Tank, K. M., Glancy, A. W., & Roehrig, G. H. (2014). Implementation and integration of engineering in K-12 STEM education. Engineering in precollege settings. In Purzer, S., Strobel, J., & Cardella, M. (Eds.), *Engineering in Pre-College Settings: Research into Practice*, pp. 35-60. Indiana: Purdue Press.

Murphy, C., Neil, P., & Beggs, J. (2007). Primary science teacher confidence revisited: Ten years on. *Educational Research*, *49*, 415-430. doi: 10.1080/00131880701717289

National Council for Accreditation of Teacher Education (NCATE). (2010). *Transforming teacher education through clinical practice: A national strategy to prepare effective teachers*. Report of the Blue Ribbon Panel on Clinical Preparation and Partnerships for Improved Student Learning. Retrieved from http://www.ncate.org/LinkClick.aspx?fileticket=zzeiB1OoqPk%3D&tabid=7

National Association of Professional Development Schools (NAPDS). (2008). *What it means to be a professional development school?* Retrieved from http://www.napds.org/9%20Essentials/statement.pdf

National Research Council. (2009). *Learning science in informal environments: People, places, and pursuits.* Washington, DC: The National Academies Press.

NSTA. (2009). *NSTA position statement: Parent involvement in science learning.* Retrieved from www.nsta.org/about/positions/parents.aspx.

Olson, J. K., & Drake, C. (2009). The home connection: Helping parents and families help your students. *Science and Children, 46,* 52-55. Retrieved from https://www.ebscohost.com

Oreck, B. (2004). The artistic and professional development of teachers: A study of teachers' attitudes toward and use of the arts in teaching. *Journal of Teacher Education*, *55*, 55-69. doi: https://doi.org/10.1177/0022487103260072

Riedinger, K. (2012). Family connections: Family conversations in informal learning environments. *Childhood Education, 88*, 125-127. doi: 10.1080/00094056.2012.662136

Rennie, L. J. (2007). Learning science outside school. In *Handbook of research on science education*, ed. S. K. Abell, and N. G Lederman. Mahwah, NJ: Lawrence Erlbaum Associates.

Rich, E. (2010). How do you define 21st-century learning? *Education Week*, *4*, 32–35.

Riegle-Crumb, C., Morton, K., Moore, C., Chimonidou, A., Labrake, C., & Kopp, S. (2015). Do inquiring minds have positive attitudes? The science education of preservice elementary teachers. *Science Education, 99*, 819-836. doi: 10.1002/sce.21177

Riggs, I.M., & Enochs, L.G. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education*, *74*, 625–637. doi: 10.1002/sce.3730740605

Ross, J.A. (1998). The antecedents and consequences of teacher efficacy. In J. Brophy (Ed.) *Advances in Research on Teaching* (Vol. 7, p. 4974). Greenwich, CN: JAL.

Rule, A. (2006). The components of authentic learning. *Journal of Authentic Learning, 3*, 1-10. Retrieved from https://dspace.sunyconnect.suny.edu/bitstream/handle/1951/35263/editorial_rule.pdf?sequence=1

Russell, J. L., Knutson, K., & Crowley, K. (2013). Informal learning organizations as part of an educational ecology: Lessons from collaboration across the formal-informal divide. *Journal of Educational Change, 3,* 259-281. doi: 10.1007/s10833-012-9203-4

Russell-Bowie, D. E. (2012). Developing preservice primary teachers' confidence and competence in arts education using principles of authentic learning. *Australian Journal of Teacher Education*, *37*, 60-74. Retrieved from https://files.eric.ed.gov/fulltext/EJ969511.pdf

Schneider, S., Dorph, R., Goldstein, D., Lee, S., Lepori, K., Venkatesan, S. (2007). *The status of science* *education in the Bay Area: Research Brief*. Lawrence Hall of Science, University of California, Berkeley. Retrieved from http://static.lawrencehallofscience.org/rea/bayareastudy/pdf/final_to_print_research_brief.pdf

Sharapan, H. (2012). From STEM to STEAM: How early childhood educators can apply Fred Rogers' approach. *Young Children*, *67*, 36-40. Retrieved from https://www.ebscohost.com

Smith, L. K., & Southerland, S. A. (2007). Reforming practice or modifying reforms?: Elementary teachers' response to the tools of reform. *Journal of Research in Science Teaching, 44*, 396–423. doi: 10.1002/tea.20165

Sutton, J., & Hatton, M. (2011). Math and science night: A twist on the traditional event to engage families in exploring and learning through inquiry. *Science and Children, 48*, 58-63. Retrieved from https://www.ebscohost.com

Tapia, M. & Marsh, G.E. (2004). An instrument to measure mathematics attitudes. *Academic Exchange Quarterly, 8*, 16–22. Retrieved from https://www.ebscohost.com

Trilling, B., & Fadel, C. (2009*). 21st century skills: Learning for life in our times*. New York, NY: John Wiley.

van Aalderen-Smeets, S.I., Walma van der Molen, J.H., & Asma, L.J.F. (2012). Primary teachers' attitudes towards science: A new theoretical framework. *Science Education, 96*, 158-182. doi: 10.1002/sce.20467

Voss, A. S. (2011). *Cross-contextual learning: Redesigning the interactions of informal and formal contexts for conceptual change*. Capstone: Peabody College, Vanderbilt University.

Weatherly, L., Oleson, V., & Kistner, L.R. (2017). Over the fence: Engaging preschoolers and families in a yearlong STEAM investigation. *Young Children, 72*, 44-50. Retrieved from https://www.ebscohost.com

Wingfield, M. E., Freeman, L., & Ramsey, J. (2000). *Science teaching self-efficacy of first year elementary teachers trained in a site based program*. Paper presented at the annual meeting of the National Association for Research in Science Teaching, New Orleans, LA. (ERIC Document Reproduction Service No. ED439956)

Yoon Yoon, S., Evans, M.G. & Strobel, J. (2014). Validation of the teaching engineering self efficacy scale for K-12 teachers: A structural equation modeling approach. *Journal of Engineering Education, 103*, 463–485. doi: 10.1002/jee.20049).

Zimmerman, A. S. (2016). Developing confidence in STEAM: Exploring the challenges that novice elementary teachers face. *The STEAM Journal, 2*, Article 15. doi: 10.5642/steam.20160202.15

Zimmerman, H. T., Reeve, S., & Bell, P. (2009). Family sense making practices in science center conversations. *Science Education, 94*, 478-505. doi: 10.1002/sce.20374

Authors

Sara L. Hartman
Assistant Professor
Ohio University, The Gladys W. and David H. Patton College of Education
Email: hartmans@ohio.edu

Danielle Dani
Professor
Ohio University, The Gladys W. and David H. Patton College of Education
Email: dani@ohio.edu