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Cultural Institutions as Partners in Initial Elementary Science Teacher Preparation

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Abstract

Despite an increased recognition of the role that 'informal' learning spaces (e.g. museums, aquariums, other cultural institutions) have in children's science education (NRC, 2015), there remains a gap between the goals and values of 'informal' and 'formal' (i.e. school-based) learning sectors. Moreover, the potential for informal spaces and institutions to also play a role in initial teacher preparation is only beginning to be realized. Here, we present our *Science Teacher Learning Ecosystem* model and explain how it frames the design of our elementary science teacher education coursework. We then use this framework to describe learning experiences that are collaboratively planned and implemented with two local museums. These course sessions engage teacher candidates as science learners and develop abilities and mindsets for bridging formal and informal teaching and learning divides. Readers are encouraged to think about their unique context and the out-of-school partners available to collaborate with, be it museums similar to those described here or parks, after-school programs, gardens, etc.

Cultural Institutions as Partners in Initial Elementary Science Teacher Preparation

Despite the widespread belief that schools are responsible for addressing the scientific knowledge needs of society, the reality is that schools cannot act alone. Society must better understand and draw on informal experiences to improve science education and science learning broadly.
- NRC, 2010

Introduction

Informal learning spaces, such as museums, zoos, parks, aquariums and other cultural institutions, are all the buzz these days. Particularly in this era of reduced time for science in school, there is increased recognition that these spaces can and do serve as important components of a child's science education (Bransford, Brown, & Cocking, 2000; Falk, Storksdieck, & Dierking, 2007; National Research Council (NRC), 2009, 2010, 2015). Out-of-school learning spaces offer experiences and opportunities that are less common in traditional classroom settings, such as choice in learning pathways, hands-on activities with authentic materials, ungraded activities, collaborative participation structures, and fluid uses of time (NRC, 2015). Through these individualized learning experiences, science comes alive, encourages developing deeper understandings about connections between the natural and physical world and the needs and interests within their own lives (Falk & Dierking, 2000). As a result, "learners may develop awareness, interest, motivation, social competencies, and practices…and identities that set them on a trajectory to learn more" (NRC, 2009, p. 27). Moreover, when more learners are able to access opportunities - across varied settings - that spark and nurture curiosity, interest, and excitement about the world they transverse, there is the potential to increase the accessibility and relevance of science to a wider variety of learners (NRC, 2009, 2010, 2015).

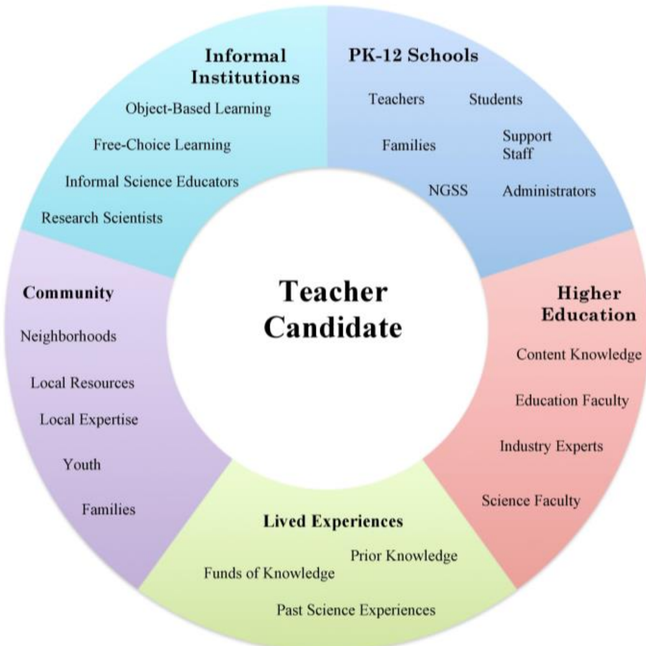
Efforts around increasing out-of-school science learning opportunities are grounded in ecological perspectives of learning (Bronfenbrenner, 1977; NRC, 2015), or those that understand learning as a dynamic, multifaceted process influenced both directly and indirectly by varied contexts, cultures and interactions. Accordingly, successful teachers are able to help students merge classroom learning and school science with prior experiences and other aspects of students' lives outside of school. In this way, students learn not for school, but for life. In 2009 the NRC's Committee on Learning Science in Informal Environments outlined a framework for what it means to learn science that consists of six strands of science learning and that builds off of the four strands of science learning put forth in the council's earlier *Taking Science to School* (Duschl, Schweingruber, & Shouse, 2007) publication. Together, these strands explain that science learning involves:

- **Taking personal interest in natural and physical world phenomena**
- Knowing, using, and interpreting scientific explanations of the natural world
- Generating and evaluating scientific evidence and explanations
- Understanding the nature and development of scientific knowledge
- Participating productively in scientific practices and discourse
- **Identifying with science as an endeavor to seek out, engage in, contribute to**

The first and last strands, as listed here, are introduced as where the informal education sector can be particularly influential. However, we argue that these two strands are too frequently ignored within the traditional formal education (i.e. school-based) sector. Substantial research indicates that these have relevance far beyond the classroom and are intimately tied to successful realization of the other four strands, which are most often highlighted as the purview of school science (NRC, 2009). We could not agree more that "these aspects of STEM literacy are not secondary goals: they are intrinsic and intertwined with understanding and engaging with STEM" (NRC, 2015, p.8).

If we are to achieve these goals, the dichotomy between the in- and out-of-school learning sectors must be overcome. ‘Formal’ and ‘informal’ educators must be able to create the types of experiences that promote all six of the strands of science learning for their students. And, for that to happen, we argue that these should not only be the goals of PK-12 science education, but also of science teacher education. Our research reveals that issues in elementary science education are connected to experience and identity building as both science learners and teachers in varied and authentic, personally meaningful contexts (Birmingham, Smetana, Coleman, & Carlson, 2015). In other words, we argue teacher candidates need to have dynamic and participatory experiences with science across a range of formal and informal contexts if they are to take a personal interest in scientific phenomena, identify with the culture and community of science and be able to promote the full range of cognitive, affective, social, and behavioral learning outcomes for their students. Additionally, candidates must also be supported in bridging the various domains in which they and their students experience science. If not, they will lack examples and models for how to help create and sustain connected learning opportunities for and with their future students.

These understandings have led us to critique our actions as science teacher educators and the types of learning experiences we provide for elementary science educators. Realizing the common shortcomings of teacher education programs that have been critiqued for a lack of experience in authentic settings and coherence between coursework and field experiences (Hollins, 2011; Zeichner, 2006), we aimed to better focus on expansive views of learning, doing and teaching science in connection to an ecological approach (Bronfenbrenner, 1977; NRC, 2015). Our elementary science teacher education coursework is designed around specific, purposefully coordinated, engaged-learning experiences for across varied science learning contexts, or what we refer to as our *Science Teacher Learning Ecosystem* (see Figure 1). In this paper, we describe how



we have expanded our thinking about the types of learning experiences we provide candidates to include those afforded by collaborations with local cultural institutions. We begin by providing contextual information about our teacher preparation program and our *Cultural Institutions for Teacher Education* (CITE) Partnership group, which consists of representatives from the university and the six cultural institutions that have been intentionally integrated as core partners. Then, we shift to highlighting key learning experiences at two museum sites that have become key spaces for science methods coursework: The Chicago Academy of Sciences / Peggy Notebaert Nature Museum (PNNM) (www.naturemuseum.org) and The Field Museum (TFM) (https://www.fieldmuseum.org). We conclude with implications for other science teacher educators interested in forming and strengthening similar types of collaborations with out-of-school partners in their areas.

Context

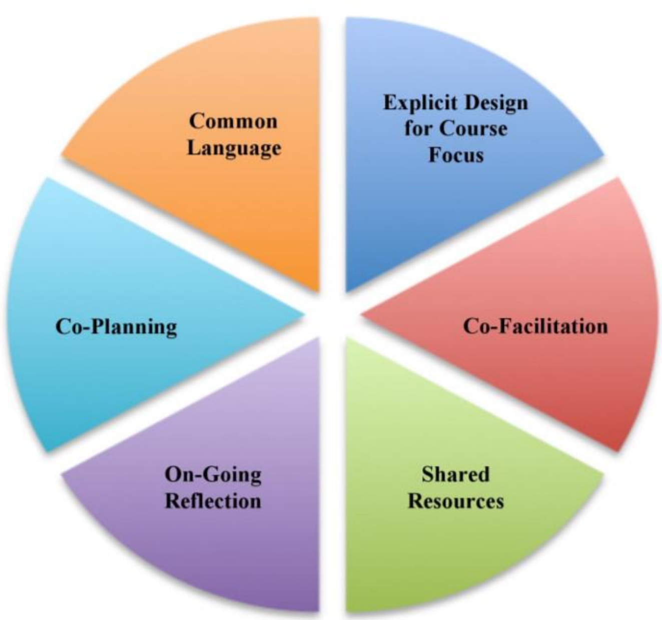
Our initial teacher preparation program, *Teaching, Learning and Leading with Schools and Communities* (TLLSC), follows a site-based apprenticeship approach in which academic knowledge is integrated with authentic teaching and learning experiences within a variety of formal and informal contexts. Approximately 80% of instruction takes place away from the university. Time spent outside of the university setting is focused on candidates experiencing and reflecting upon learning in PK-12 schools, local cultural institutions, and various community spaces. Across these learning contexts, university faculty work in collaboration with other educators and community stakeholders to prepare candidates for culturally and linguistically diverse urban schools. For the purposes of this paper, we focus on learning experiences embedded in an elementary science methods course typically taken during candidates' sophomore year in the teacher preparation program. The course is designed to introduce candidates to learning and teaching with inquiry across different contexts and through interactions with a diverse range of educators (see Table 1 below).

Table 1. Course Overview

Focus/Guiding Questions	Locations	Educators
1. What is scientific inquiry? 2. What does scientific inquiry look like in varied contexts? 3. How do we help students connect science learning in and outside of the classroom? 4. What does it mean to teach through inquiry in K-8 classrooms?	➢ Bio-diesel laboratory ➢ K-8 classrooms ➢ Nature Museum ➢ The Natural History Museum	➢ University faculty ➢ Environmental Scientists ➢ K-8 teachers ➢ Museum educators

Learning experiences in this course are directed at challenging and expanding candidates' conceptions of what science is and what participating in science can look like. We believe these experiences are vital for building productive science identities (as a learner and teacher), seeing how science matters in their everyday lives and envisioning the possibilities for science learning and doing in their future classrooms. Thus, we seek experiences where candidates have opportunities to first see themselves in science, find relevancy for their science learning, and work towards feeling confident in helping their students do the same.

Local cultural institutions – including their education staff, collections, programming and pedagogical approaches – have been intentionally integrated as true, mutually beneficial partners in initial teacher preparation. Even before the launch of the re-designed, field-based teacher preparation in Fall 2013, the first author and other faculty in science and other content areas had relationships with area local cultural institutions and it was important to us to give these further prominence in the re-designed program. Such partnerships afford candidates opportunities to develop pedagogical skills, deepen their content knowledge, interdisciplinary thinking and practice, build professional relationships with informal educators and institutions, and access resources for classroom application. The cultural institutions are interested in connecting with educators before they first enter the classroom, with the potential to have an early influence on their thinking about how to utilize their institutions and resources from the start; more typically professional development occurs with teachers already in the field. Figure 2 summarizes key facets of this intentional integration of local cultural institutions into our current program.



Regardless of their specific area of specialization, all candidates have multiple opportunities to work with museum partners beginning in the first semester in the program. Elementary education candidates continue to have in-depth experiences in their second year with those museums and other cultural institutions that have science as part of their educational mission. These experiences are co-planned and co-taught by university faculty and museum education staff. University instructors share course syllabi and relevant assignments to inform and contextualize session design; museum educators share lessons learned from their work with practicing teachers and families. Additionally, we meet regularly as “co-teacher educators” to debrief, examine student data, reflect on course outcomes, and revise plans as needed. These meetings often take place via Skype or phone, or around monthly CITE meetings.

***Cultural Institutions for Teacher Education* (CITE) Partnership**

As part of this collaborative approach to initial teacher preparation, the CITE Partnership formed as a working group in the Fall of 2014 in pursuit of two goals: enhancing collaboration and disseminating findings. We sought to create a space for open communication about our work as teacher educators, including challenges and opportunities that arise and how we might support and learn from one another. We also sought to think more intentionally about how we communicate our work with varied audiences through multiple formats, and how we might open and contribute to dialogue with others about this collaborative approach to initial teacher education.

Currently, there are six institutions and 14 people involved in monthly CITE meetings, which alternate across the member organization locations. We have a half-hour set aside for “coffee and conversations” to start each meeting to allow for socializing and catching up on any individual concerns; we then have two hours set aside for the regular agenda which is set by the two faculty leads with input from other members. This core group provides overall leadership and organization, but there are additional university faculty and cultural institution staff involved in class sessions. Table 2 describes the range of educators and institutions represented. Some of the institutions are more involved with elementary science education coursework and others with other program coursework (i.e. early childhood, history education). One of the first projects for the group was to collaboratively develop a dynamic logic model that continues to guide our long-term efforts. This development process helped us to build collective understanding of the intentions and goals of each member organization and of the group as a whole. It also helped to clarify roles of each institution in supporting goals according to each member's strengths and expertise, and highlighted and justified strengths of a partnership model for teacher preparation. Coming from different perspectives, we developed shared vocabulary that facilitates work with candidates and adjunct faculty. The goal articulation process also uncovered and gave us the means to better address concerns of existing members as well as new members as they join.

In addition to planning, implementing and reflecting on the teacher preparation courses, CITE currently has three working research groups studying various aspects of the partnership including: implications for science teacher education, child development and learning theory coursework, and the collaborative development of a logic model that guides the group's long-term projects.

Table 2. CITE Partnership Composition

Participant	Date Joined CITE	Type of Institution
1	2014	Science Museum
2	2013*	Children's Museum
3	11/2015	Children's Museum
4	2013*	Natural History Museum
5	6/2015	Natural History Museum
6	2013*	History Museum
7	2013*	History Museum
8	9/2015	Science Museum
9	9/2015	Science Museum
10	2013*	University
11	2013*	University
12	8/2014	University
13	11/2015	University

* indicates that the member was involved with university prior to the formation of CITE

Course Experiences

The semester-long course sequence, *Specializing in an Area of Teaching and Learning: Integrated Instruction in Elementary Classrooms*, consists of two, three-credit course modules that emphasize the common practices shared across science and history/social studies, with an emphasis on integrating writing across these content areas. The modules run back to back, with candidates moving from a focus on science to a focus on social studies at the semester mid-point. This condensed, focused approach allows for extended time at partner sites; these three-credit classes meet two days per week for four hours each day over six weeks. While there is a dedicated classroom

Introduction to Session/Announcements
Goal: To synthesize ideas encountered throughout the course related to engaging students in Strands of Science Learning. To gain a deeper understanding of how teachers can begin to connect students' learning experiences in informal and formal environments.

Introduction to PNNM – History & Programs
Goal: To provide teacher candidates background information on NM and its resources.

Introduction to Citizen Science at PNNM
Goal: To model a science talk. To promote candidates' bringing citizen science into the classroom.

Introduction to Inquiry Experiences with PNNM
Goal: To provide teacher candidates with an opportunity to participate in a local ecology investigation. To promote teacher candidates making their own connections between the 5E learning cycle, and other learning cycles/models.

Using PNNM Resources to Design a Learning Experience
Goal: To use PNNM exhibits and resources as a starting point for designing instruction, thereby connecting student learning experiences within the classroom to non-formal learning experiences at PNNM and other spaces.

Wrap up
Goal: To elicit teacher candidates' thinking and questions on how they might integrate informal science education institution resources into their future science instruction.

Figure 3. Sample PNNM visit agenda

available on campus, the majority of class sessions take place at the various field sites. Partner sites are accessible by public transportation from the university and the instructors meet candidates on site. With one full-time science education faculty, adjunct professors play an important role. Class sizes are small, approximately 10-12, to allow for site visits. Each spring semester, there are typically between two and three sections of the course modules, each of which has a different specified school partner. The school partners are selected based on their strengths and/or needs as relates to elementary education. For instance, one school has a dedicated primary engineering lab that serves as an exemplary model for candidates; another school has expressed an interest in bolstering its science program and is eager for support from the university faculty.

The Chicago Academy of Sciences / Peggy Notebaert Nature Museum visit. The visit to PNNM (see Figure 3) comes mid-way through the course, after the class has been introduced to the *Strands of Science Learning* and the *Framework for K-12 Science Education*. They have spent time in elementary science classrooms, attending to the ways teachers and students engage in science teaching and learning. They have also begun conducting their own personal inquiry projects that explore a local sustainability issue of their choosing. This visit, co-planned and co-taught by university and museum educators, engages candidates as both learners and teachers of science as it exposes candidates to museum collections and spaces as well as instructional approaches and models frequently used by the museum in their programming. The university faculty sets the stage for learning at the start of the visit. Throughout the visit the faculty engage candidates in making connections between their course readings and other class experiences and the museum visit discussions and activities. The museum educators have familiarity with the course syllabus and objectives, and so can help to facilitate these conversations. For instance, both faculty and museum educators prompt candidates to reflect on ways that they themselves encounter the strands of science learning throughout their visit, as well as ways that they might incorporate museum resources into their classroom instruction. Candidates meet museum education staff, learn about professional development opportunities and programs for school groups, and explore the *ITW David and Barbara Speer Teacher Leadership Center* (TLC) which functions as an open work space for educators. The TLC houses a professional library and the curriculum loan boxes with preserved specimens, multi-media resources, field-guides, and lesson activities that can be checked out for free. They engage in a science talk about local wildlife as they learn about the citizen science initiatives at the museum, such as *Project Squirrel* (http://projectsquirrel.org) which involves observing and recording sightings of fox and gray squirrels that serve as indicators of local ecology. Then, candidates participate in a local ecology investigation that follows the museum's inquiry model, their take on the learning cycle model that candidates have read about and experienced in the school classrooms. By this point they are eager to engage in conversations focused on developing a plan for how they will use materials from one of the loan boxes during a science talk and subsequent investigation that they plan for and conduct with elementary students in their partner school classroom.

The Field Museum visit. The visit to TFM (see Figure 4) comes toward the end of the course and marks the transition from the science-focused module to the social studies-focused module. As a natural history museum with four integrated areas of study (anthropology, botany, geology, and zoology) TFM provides candidates with various examples of the interdisciplinary approach many TFM scientists must employ to answer complex questions and solve challenging problems. This serves as a model for authentic, interdisciplinary inquiry investigations in the classroom. The session is collaboratively developed and facilitated by university faculty and museum educators optimizing opportunities to feature classroom applications for instructional strategies traditionally reserved for museums. In this session object-based learning and interdisciplinary inquiry serve as the primary foci. Candidates learn about the important role of The Field Museum's scientific collection in research and conservation and are introduced to the *N. W. Harris Learning Collection*, a lending library of artifacts and specimens that are lent

Welcome and Introduction to The Field Museum
Goal: Set student expectations for the session and pre-assess candidates' knowledge of The Field Museum and its collection.

Introduction to Object-based Learning
Goal: Begin to explore the instructional strategy of using objects as a focus of inquiry. Make observations and inferences with a single object and practice teaching and learning using museum collections.

Overview of *Restoring Earth* and the Science Action Center
Goal: Introduce the research and conservation work of the Science Action Center at TFM as an authentic model for integrated inquiry, and set expectations for exploration of the exhibition Restoring Earth.

Exploration of *Restoring Earth*
Goal: Examine how interdisciplinary teams of scientists and social scientists work to understand and conserve the complex ecologies and social systems of the Andes Amazon and nearby Chicago region.

Applying the Models
Goal: Reflect on new understandings of how scientists approach complex questions through interdisciplinary research and how that applies to candidates' personal inquiry projects.

Wrap-up
Goal: Reflect on how candidates might utilize the methods and resources at The Field Museum in a classroom setting.

Figure 4. Sample TFM visit agenda

to teachers for classroom instruction. Taking on the role of learner, candidates practice 'reading' a single object using an Observation/Inference framework and apply this skill as they begin learning from collections of museum objects. Candidates then examine the work of TFM's interdisciplinary team of scientists and social scientists in the Science Action Center through the lens of their personal inquiry projects. After a brief introduction to the work of the team, candidates explore this team's research and conservation work globally in the Andes Amazon and locally in the Calumet region of Chicago by visiting the *Restoring Earth* exhibit. After returning from the exhibit, candidates reflect on the interdisciplinary approach taken by the Science Action Center and how applying the lenses of multiple disciplines may lead to new insights in their own inquiry projects and in the classroom.

Teacher Candidate Outcomes

At the start of their preparation program, teacher candidates are usually excited to see that the syllabi include trips to area museums. However, they also question, why are we going? They often remember visiting any variety of informal science spaces, either with their families or on field trips, but think more of those visits in terms of entertainment as opposed to educational value. They are surprised to learn that there are education departments, staff, and programming especially geared toward teachers. They are even more surprised to learn that as teacher candidates, these resources are open to them too. By introducing candidates to the science-focused museums early in their preparation program, we seek to build their awareness of the extensive and varied resources available to them and their future students, including the science and educational staff's expertise, curricular materials, pedagogical approaches and programming. Yet, beyond this, we aim to support them in interrogating what it means to learn, do, and teach science. Further, we want to activate portions of their learning ecologies that exist outside of school experiences in the process of this interrogation. Interested in the outcomes of teacher candidate learning experiences in these informal science learning spaces, we looked at a variety of course artifacts, including anonymous exit slips completed at the conclusion of visits, course reflections, and informal course conversations. These indicated that the visits helped candidates to see the museums as educational spaces for teachers and students alike and as valuable partners in education. Candidates began articulating how they might leverage elements of the learning they experienced in the museum spaces – and other areas of their lives – for their future teaching in classroom spaces.

We found that the experiences influenced candidates' conceptions of learning and doing science as well as what is possible in their future classrooms. In particular, candidates expressed that the learning they were experiencing in the museums was representative of what they wanted science learning to look like in their future classrooms, despite not always aligning with their own prior experiences as K-12 students, which was more didactic or hands-on activity-mania. This vision of science learning and doing they experienced in the museums included three interconnected elements. First, candidates wanted their future students to see how science can and does matter to them and their lives as they did through their explorations with museum educators. They felt that the pedagogies they were introduced to in the informal spaces especially valued the knowledge and experiences they brought to the activities. Second, candidates wanted their future students to understand that science was a collaborative endeavor that is strengthened through active participation. They felt that this was modeled both in the museum exhibitions they visited as well as in the learning activities they took part in. Finally, candidates wanted their future students to understand that doing science is a dynamic process, leading candidates to challenge the rigid and static conceptions of the scientific method they experienced so often in their formal science classrooms. We see candidates' identifying powerful elements of their own learning experiences at the museums to be a first step in the expansion of their thinking about where and how teaching and learning science occurs – a necessary step in order to bridge the informal-formal divide.

Going Forward

The learning experiences described here are the result of deep collaborations between the museum and university teacher educators. By working as co-teacher educators, we communicate to candidates that we know and value that science, teaching, and learning occur across the many places of our lives, not only in a classroom (or only in the museum for that matter). Rather than ignoring out of school spaces and the two strands of learning that they are most often associated with, educators need to be purposeful about integrating these visits within the elementary science teaching coursework brings them to the forefront. Further, partnerships between the traditionally disparate realms of formal and informal education opens up the possibility that the learning experiences in any given aspect of one's learning/teaching ecosystem can be leveraged in another. During the visits, museum educators help model for candidates how all six strands of science learning can come together in a learning experience. Teacher candidates come to see how these strands, like the various components of our personal learning ecologies, interact in complex, synergistic ways. For instance, candidates found that the object-based learning approaches introduced at TFM promoted a *personal interest in natural and physical world phenomena* because it recognized the unique knowledge and experiences they each brought and also provided a common experience to anchor subsequent instruction. Similarly, candidates found that the citizen science initiatives introduced at PNNM offered ideas for subsequent opportunities to engage in scientific investigations related to their own neighborhoods and communities, promoting their *identification with science as an endeavor to seek out, engage in, contribute to*. The intersection of these strands and legitimizing of multiple learning ecologies can lead to motivating and exciting learners (be it themselves or their students) about science, allowing them to acknowledge the many ways in which we come to know, use and contribute to science.

We do not mean to suggest that experiences described here are an ending point, rather we aim to communicate how providing these sorts of learning experiences that trouble traditional notions of where science, learning, and teacher preparation occur can activate other areas of candidates' learning ecologies, and subsequently support their students' in doing the same. Similarly, as a reader, we hope you will think about your unique context and the out-of-school partners available to collaborate with, be it museums similar to those described here or parks, after-school programs, gardens, etc. As teacher educators, we must ask ourselves what vision of science learning and doing are we promoting? How do the learning experiences in our courses address the six strands of learning science and the diverse learning ecologies candidates bring to science? If we are to successfully promote science learning as broader than schooling, we must broaden teachers' learning ecologies.

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