

ROUTLEDGE RESEARCH IN EDUCATION

Intersections of Formal and Informal Science

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14 Breaking Dichotomies

Learning to Be a Teacher of Science in Formal and Informal Settings

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This past decade has yielded a deeper understanding of how formal and informal learning contexts are not at odds with one another but rather complement each other. The formal and the informal environments create ecology of learning spaces. When learning occurs at the nexus of formal and informal learning spaces, leveraging the affordances of both spaces, that is when students not only engage with the endeavor of learning science but also are prepared to carry out the practices of science. Teachers need to be prepared to maintain an identity of not just a schoolteacher, but a teacher of science, one that crosses boundaries of teaching in both formal and informal spaces and one that espouses a reform-minded identity steeped in a worldview that privileges science inquiry, where the teacher believes that a learners' prior knowledge and everyday experiences are critical in the process of learning, the goal being to steer youth toward science literacy by deepening understanding of specific core foundational topics (Avraamidou, 2014).

Informal science learning environments can be broadly defined as non-school settings that offer opportunities to experience and make meaning of scientific phenomenon. These environments range from a schoolyard to an amusement park. For the purpose of this chapter, informal science learning spaces are structured institutions, such as museums, zoos, aquaria, and gardens. These institutions are where people can engage with science in ways that are authentic and participatory. The resources in informal science learning spaces include exhibits, collections (living and nonliving), educators, scientists, and science labs. These resources are important in supporting teachers and, in particular, those learning to become teachers, because they afford the opportunity to enact culture in particular ways that contribute to reform-minded teaching (Luehmann, 2007). The affordances of learning to teach in such settings include opportunities to work with multiple and diverse audiences thereby mastering one's skill at student engagement, being comfortable to teach the same content to different audiences, time to refine the lesson, and the opportunity to develop an awareness of self as a teacher and a learner, which all contribute to identity development as a science teacher (Gupta & Adams, 2012). We take teacher identity to be "the ways in which a teacher represents her views, orientations, attitudes,

emotions, understandings, and knowledge and beliefs about science teaching and learning” (Avraamidou, 2014, p. 826). We use this definition to illuminate how a person’s identity as teacher of science becomes visible through enactment of culture and is always transforming. The practices of that teacher are an embodiment of her ideas and beliefs and how she uses available resources.

In this chapter, we examine the affordances of museum resources in informal settings and how they shape science teacher identity. More specifically, we discuss how residents learning how to teach in school settings leverage experiences of learning to teach in museum settings. We describe a masters of art (MAT) program that is situated at the American Museum of Natural History (AMNH). The MAT, an earth science teacher preparation program, is a 15-month residency program. People with undergraduate degrees in earth science/astronomy or a closely related topic can apply with the intention of becoming certified to teach earth science in New York State. These people hereby referred to as residents, undergo a program that begins in June and consists of two museum residencies and two school residencies. Residents also complete 36 credits of science and education courses, which are co-taught by science and education faculty, many from AMNH. The two museum residencies serve as bookends for the 15-month program. Upon graduation from the program, the cohort of teachers participates in a two-year new teacher induction program at AMNH.

In the first museum residency, teacher candidates rotate through three distinct museum activities that build on their instructional abilities to use informal science resources. This eight-week residency provides experiences with everyday museum visitors and middle and high school students enrolled in museum youth programs. In the first two weeks of the rotation, residents work in small teams with interactive museum touch carts in the museum halls. Residents spend about 20 hours with the museum touch carts in the halls, which provide many opportunities to engage and assess visitors’ prior knowledge, and introduce science concepts and assess for understanding. During the second rotation, residents get an in-depth experience observing and co-teaching with museum educators while working with middle and high school students who participate in weeklong and month-long museum youth programs. In the third rotation, the residents have the opportunity to design and teach their own lessons for high school students who are invited for a summer science institute. During the museum residency, residents take a course that provides the theoretical foundations for learning in informal settings.

In the second museum residency, residents spend time learning in the field and doing research with museum scientists. This experience allows residents to collect rock and mineral specimens to use in their instruction. This chapter focuses on what we are learning from the first museum residency and how teachers are enacting museum resources in their own teaching once they become teachers.

MAT graduates participate in the new teacher induction program, which takes a multilevel approach to supporting and developing new science teachers. The program consists of school visits with classroom coaching, monthly meetings at the museum, and 30 hours of professional development. During this time, teachers become part of a professional learning community, share their student work as well as participate in activities to improve their facilitation of student discussions and deepen science conceptual understanding using museum resources. To date, 50 candidates from three different cohorts have graduated and are teaching in high-needs public schools (defined as schools with at least 70% of students living below poverty level). The cohorts consist of 50% men and 50% women, 18% Black or Hispanic, and 37% career changers.

EMERGING IDENTITIES AS TEACHERS OF SCIENCE

Learning to teach is a cultural activity, one that is shaped by the contexts of the environment but also shaped by one's own sociocultural and political standpoints. We describe cultural activity as occurring in a field, where culture is produced, reproduced, and transformed (Sewell, 1999). Fields are sites of activity with porous boundaries and have structures, both visible and invisible and those structures consist of resources (material, societal, cultural) and schema. Resources may include objects, people, tools, and rules, and schema are the ideals and beliefs one holds. One's practices are a set of actions that draw from one's schema and available resources. If we claim that the museum is a field, then we can say that as residents work in these fields, they are using the structures of the field to afford them the power to act, to have agency. As a resident becomes agential in the field, she actually mediates changes to the structures of that field. One way to visualize is by using the Scheffer stroke "l," which denotes dialectical relationships (Roth & Lee, 2007). Then we can represent the concept as such, structure | agency where structure is defined by the dialectical relationship of resources | schema.

When residents operate museum touch carts, they are enacting culture in the museum. They are using the resources and schema available to them. At each interaction with a visitor at a cart that contains objects, the resident has to act in compliance with the resources available and the schema that exists in that moment in time. The person also has to experience passivity (Roth, 2007). After a resident asks a question or poses a challenge, the visitor's actions and words are unpredictable. The resident has to accept this reality and experience this state of being and then be ready to act in response to the moment before, and use the structures available in that new moment. In this way, each interaction becomes a time to use and simultaneously transform structures. Each successful and unsuccessful interaction mediates the way resources are used and schema is developed. After 20 hours of facilitating

with the museum touch carts, their agency at teaching at the carts is greater than it was when they started. Because it is a dialectical relationship, as their agency increases, the structures also change at that cart. The way the objects are used and the nature of the conversations with the visitors are different. The resident develops the ability to act and maneuver in different ways in response to visitors. She develops strategies for how to engage visitors. In the vignette that follows, we see how one particular resident discovers the value of creating a challenge at the museum touch cart.

During my first rotation at the Ocean Life museum cart, I had two children extremely excited about finding out about the sperm whale's tooth. Since they were so hyper I sent them down to see the diorama and told them to come back to tell me what they have seen. A few minutes later, they came back but they didn't have the right answer so I asked them if they wanted me to tell them or they wanted to continue their adventure. They decided to go back downstairs to check again. When they came back they were jumping and screaming that it was a sperm whale and a huge squid. But when I asked them to whom the tooth belonged to, the boy said it was a squid's tooth and the girl said that it was the whales. I had the boy tell me why he told the tooth belonged to the squid and then I had the girl explain to the boy why the tooth belonged to the whale.

Natural history museums are built on the foundation that objects in their collections tell an important and compelling story. Learning how to teach with objects takes time, and one needs to develop strategies that are comfortable, effective, and make sense for the curricular goals. In the vignette, the resident has discovered the power of engaging learners by posing challenges and reveals how she connects an object to a set of exhibits. In the following vignette, we see how a different resident is developing an appreciation for object-based learning but also incorporating a learner-centered pedagogical approach.

When a large group gathers around the cart, it takes much more awareness on the part of the educator to keep everyone involved and engaged. I am far from mastering this skill, but so far have found that passing the cart objects around the group and getting everyone involved in brainstorming answers to a more difficult question help maintain the large group interactions. At this point in the museum residency I am just beginning to explore what techniques and resources I find most effective in certain context (e.g. different age groups, cultures, group sizes). I have walked away from this past week's discussions, readings and observation of cart use with a better understanding of the importance of object-based learning and the role that questions can play in creating a more engaging and open learning experience.

The two vignettes illustrate the trajectory of how the residents develop a comfort with using the objects by trying different strategies with different people. Short interactions with numerous visitors' means that each time the resident uses the resources of the museum touch cart and engages the learner, it mediates changes in her schema. Each interaction makes her think about learners and learning differently. As her ways of thinking about how to interact with people changes, her use of resources on the cart changes. As the resources | schema dialectic continues in each interaction, her practices change. As the residents are successful with visitor interactions, they are seen as a certain kind of a person by their peers and by visitors, a person who knows how to teach science. Over time, they begin to see themselves as successful teachers of science, and this mediates changes in their identities. Identity development becomes intertwined with the act of doing. Because the construct of identity is dynamic and fragile, often, unsuccessful interactions can lead to threats to one's ability to teach. However, because residents are required to spend 20 hours on the museum touch carts, there is the opportunity to learn from the unsuccessful interactions and to use resources and apply practices differently. Unsuccessful interactions can become a way to revise a teaching strategy, which then can lead to a successful interaction. The unsuccessful interactions, which may emotionally challenge one's self-perception of being able to teach, are followed by a successful interaction, which balances emotions. Because the nature of working at museum touch carts means many short interactions in a chain, each interaction becomes a chance to start over, and the rate of successful interactions is far greater than the rate of unsuccessful ones. A resident begins to identify with what teaching with objects means and this is not a shallow understanding, but one steeped in multiple lived experiences, with each time being given a chance to apply practices differently as governed by the resources | schema dialectic.

THE AFFORDANCES OF EXHIBITS

Whereas objects can be brought into another learning space, exhibits often cannot be replicated in the same way. Field trips become the primary way for accessing and using the exhibits for schoolteachers. Field trips, especially for new teachers, can be a daunting task for reasons that include uncertainty of the teacher's role, lack of comfort with the content, logistical challenges, and administrative obstacles (Kisiel, 2014). To combat some of these issues, the MAT program aims to develop comfort and confidence at facilitating field trips. The second rotation in the museum residency places residents in co-teaching roles with various expert museum educators who lead a three-week summer program for middle and high school youth who are in a museum program that is designed to teach key concepts of anthropology, biology, and physical science in ways that fully integrate the exhibits

of the museum with classroom activities. The summer program is designed so that students visit exhibits each day and over the three-week period with different museum educators. When residents are working with a number of the museum educators throughout these three weeks, they observe multiple teaching styles and multiple approaches to using the exhibits in a lesson. In the following vignette, we experience a resident who believes in the value of informal learning spaces and is pondering how to use non-classroom experiences to augment the formal learning space.

The instructor for the sixth grade biodiversity program jumped into museum on the first day with visiting the Halls of Biodiversity and Ocean Life. He then followed up with another assignment that required a visit to the Hall of Reptiles and Amphibians. The kids also did an activity that required them to virtually gather anthropological items to create their own museum collection.

Having multiple opportunities to see how children get engaged at exhibits, get excited, and bring that excitement into the classroom is important for aspiring teachers, because it allows them to imagine and understand what good museum learning experiences can look like. When residents experience and compare the different pedagogical approaches taught by the museum educators and observe the way that children respond to those approaches, they are able to create a schema for themselves that consists of strategies and successful experiences. The museum educators have their unique style, but all use instructional strategies to engage children with objects on display in a natural history setting. During this rotation, residents observe and reflect on how particular approaches are used, such as sketching dioramas, talking in front of large-scale specimens, and using worksheets to gather evidence in exhibits. The residents realize that using the exhibits as a resource and with a particular schema associated with it allows children to exhibit their interest and abilities in multiple ways.

Residents take courses throughout the academic year that follows the first museum residency. In one of the courses, there is an assignment to develop, implement, and assess a museum investigation that is embedded in a specific unit of instruction for students at their residency schools. The goal of the assignment is for residents to build on their summer museum residency experience by integrating museum resources into the school curriculum. It is the nexus of bridging the formal school with the informal learning experience. Residents are asked to reflect on student work and share insights for the evidence for student learning. When the residents conducted their museum investigation assignments in this course, it was not surprising to see that they chose numerous exhibition halls within the museum where they had spent time during the museum residency. Residents were asked to reflect on the field trip experience and in particular focus on the work produced by the students on the trip. In the vignette that follows,

we see how students in a special education class thrive during the museum experience. The resident states,

I took seven kids from a marine science class which I have been taking the lead on for most the semester. Attendance and excitement was just not there. They attended irregularly. They needed something. Excitement about the subject was there but museum trip would be perfect. It would get them excited about anything they wanted, but I would try and direct them to the ocean life stuff when we got there, because that is what we were doing. We had done an intro before, to get a sense of marine environment. I tried to do a lesson but it was so boring for them even though we had some visuals, but they weren't great. But then, dioramas on top of the Ocean Life Hall you can see the environment, they are everything short of interactive. They loved it. Then I said pick your favorite. They all went to the polar seas one. They got excited about that part of it. After they were done with their worksheets. It was nice to see them put down the sheets and actually look, instead of looking with something in mind, and then they had all kinds of questions and their work was fine, it was accurate.

Because the visit was a field trip as part of a formal school structure, worksheets and assignments were used to check for student understanding. The aforementioned resident had a reform-minded approach, one that was learner-centered, and grounded in the learner's interests. For the assignment, she asked the students to choose an ecosystem to learn about it in the Hall of Ocean Life. She leveraged the free-choice learning mantra of informal learning settings to give them power over their own learning. A number of the residents reported that because of the experience in the museum residency they knew the value of letting their students have options for their own learning on the field trip. For this to happen, residents needed to trust the students and trust the potential outcomes of having them lead a portion of their own learning experience.

The museum investigation provided an opportunity for this resident to get to know students in a different way. The museum and the school are both fields of activity, but these fields have porous boundaries. Residents who have learned to use the structures of the museum carry that agency and associated structures into their formal classroom space and then back. As they enter back into the museum learning space, they now have the structures learned from a formal environment mediating their agency. The dichotomy of formal and informal learning spaces breaks down. The structures and associated agency developed in both fields now mediate activity in both fields.

THE JOURNEY CONTINUES

The first three cohorts of the MAT residents are now first- and second-year middle and/or high schoolteachers. The teacher shifts from being a student in

the MAT program to teachers in new teacher induction. We observe the shift in their identity from MAT resident to new science teacher. One of the goals of induction is to use the affordances of the museum to nurture the teacher's own informal learning and strengthen their ability to use museum resources, especially while their new teacher identity is in flux. The shift of forming identities as reform-minded teachers takes time and is influenced by context and experiences early on in teaching. One activity in the induction program is to support teachers in developing their abilities and nurturing their own passion for learning. Teachers engage in various strategies to observe, draw, and talk about a specific diorama or museum exhibit. Afterward, teachers reflect on how to translate these types of experiences into their classroom instruction.

By the time the teachers begin new teacher induction, they are comfortable planning museum learning experiences and using objects, but whether they actually plan and carry out depends both on their school context and their identity as a teacher and learner. The MAT teachers exhibit practices that convey their interest in using objects and the physical resources at the museum. In the first four months of teaching, 56% of the teachers ($n = 42$) made a visit to AMNH and by the end of the first year, 85% had visited AMNH or another informal learning site. The teachers who visited late in the year regretted not taking their students earlier because of how much the students learned and how the teacher was comfortable facilitating in the museum.

In documenting the experiences of particular MAT graduates who brought students for a field trip, we saw evidence of their transforming identities as people who feel the museum is an extension of their classroom and is a place where they can engage their students. We also saw the power of being seen as a certain kind of person by both students and administration, a person with access to the museum, and a person with passion and expertise in the science.

Dan

One teacher, Dan, was struggling with making his lessons active and was met with some resistance by his students. He was challenged to connect with his students and was afraid to take a field trip. He did so after hearing about another MAT graduate who taught in a similar school setting and how the field trip was successful for the students. In the third month of school, Dan brought his class to the museum, and he began to use the museum resources such as the geology exhibits that he knew well and drew upon his associated schema for teaching with those resources. He exhibited confidence, a comfort, and an agency in teaching his students. He later reported that the visit became a turning point for his relationship with his students. Dan had a museum badge, access to particular exhibits that normally cost additional money, and was being treated by the museum as if he belonged there. He stated that students talked about the trip once they returned to school, and

he received some "cred" in the student's eyes for providing a trip that did not cost money and had extra access. They also respected his ability to use the exhibits with ease and passion. Dan's practices were comfortable in the museum because he had the agency to use the exhibits proficiently. His students saw this fluent practice and now identified him as someone who knows science, is passionate about science, and is linked to an institution of science. Although he had the ability to practice reform-minded teaching in the school environment, his students were not affording him the structures necessary for success. When they experienced his practice in a field that was outside of their comfort space, their schema about what was possible changed. When he returned to a formal school structure, the students were carrying back this schema and afforded him the space to teach science and to use the agentic practices he exhibited at the museum.

Mina

For some teachers, whereas field trips were not options immediately available because of school structures, their identities as reform-minded teachers allowed them to exhibit themselves in different ways. Mina's story provides an instructive example of bringing the museum resources into the classroom. Mina placed pictures of herself in the field collecting rock samples with her MAT colleagues on her classroom walls. She had rock samples that she had collected showcased in her classroom. One of her first student assignments was to have students take their own photos in a place where geology is found in the city. In her classroom, she had many of these photos of her students standing in a park, near a river, or on a rock. Throughout the year, Mina kept using museum resources in her classroom. She invited two scientists to her class that she had worked with in the MAT program. Although it appeared that she is an ideal candidate who would conduct a field trip, she was challenged by school administration.

In February of her first year of teaching, she asked her principal if she would be able to bring students and parents on a weekend day to visit AMNH. She came to realize that if she visited on the weekend, her principal really could not refuse. She worked with the parent coordinator and planned a trip for a Sunday in May for about 70 students and 50 parents. The trip was pivotal at stabilizing her teacher identity. One of the parents who went on the trip was so impressed with how much the students and parents learned, the parent called to inform the principal. It was this call from a parent that shifted the principal's idea toward trips. But it did something for Mina also. Mina believes her principal saw her as someone who had "cache," a resource by having an affiliation with the museum. The principal's ambivalence toward trips dissipated, and Mina stepped into taking a leadership role at the school leading to a number of school partnerships with AMNH. Mina had the agency to keep bringing resources into her classroom and ultimately planned a weekend trip. Being seen as a certain kind of person by the parent mediated the actions of that parent to talk with

the principal, which led to the principal to see Mina as a certain kind of teacher—a teacher with access to AMNH resources and, more critically, the ability to engage students and parents using the affordances of the museum.

IMPLICATIONS

Informal science education institutions are critical partners for teacher preparation. The opportunity for aspiring teachers to use the affordances of such settings allows for a shaping of identity that blurs the lines of formal and informal learning and allows teachers to use the resources of such settings in varied ways to engage learners, garner respect for themselves from both adults and students, and develop a sense of self as a teacher of science that is strong. We describe a number of affordances that museums offer that position aspiring teachers to practice teaching in low-stakes settings, with objects, to diverse learners and work alongside many different experts, each time building a framework for what good teaching looks like. Throughout the program, opportunities to exercise those strategies are present, leading to relative comfort and familiarity with conducting field trips. As these aspiring teachers become teachers of record, we see threads of evidence of how the particular schema trigger practices that lead to using the affordances either in the form of science activities, object-based teaching, or science museum investigations.

There is much to be learned as the AMNH MAT continues to graduate more science teachers. In particular, we are curious about the extent to which MAT graduates are using informal resources in instruction to strengthen student understanding and engagement in science. However, we hope that the ideas presented will support others to document their experiences working with teachers in informal settings and to build on how these experiences shape teacher identity and strengthen instruction for all students. There are more than a thousand different science museums in North America and many of them are situated near institutions of higher learning. Many already have partnerships with each other. What are the opportunities to develop ways for aspiring teachers to work in such places where they can practice teaching in low-stakes settings using different exhibits and objects with intergenerational visitors? How can museum faculty work with higher education faculty to create structures and processes to weave theory into practice? How can museums be used for supporting new teachers through induction experiences? These questions and many more are critical for consideration as we experiment with teacher preparation at the nexus of formal and informal learning settings.

REFERENCES

- Avraamidou, L. (2014). Developing a reform-minded science teaching identity: The role of informal science environments. *Journal of Science Teacher Education*, 23, 823–843

- Gupta, P., & Adams, J. (2012). Museum-university partnerships for preservice science education. In B. J. Fraser, K. Tobin, & C. McRobbie(Eds.), *Second international handbook of science education* (pp. 1147–1162). New York, NY: Springer.
- Kisiel, J. (2014). Clarifying the complexities of school-museum interactions: Perspective from two communities. *Journal of Research in Science Teaching*, 51, 342–367.
- Luehmann, A. (2007). Identity development as a lens to science teacher preparation. *Science Education*, 91, 822–839.
- Roth, W.-M. (2007). Theorizing passivity. *Cultural Studies of Science Education*, 2, 1–8.
- Roth, W.-M., & Lee, Y.-J. (2007). “Vygotsky’s neglected legacy”: Cultural historical activity theory. *Review of Educational Research*, 77, 186–232.
- Sewell, W. H. (1999). The concept(s) of culture. In V. E. Bonnell & L. Hunt (Eds.), *Beyond the cultural turn: New directions in the study of society and culture* (pp. 35–61). Berkeley, CA: University of California Press.