

Discovering Science Teaching and Learning in a Hands-on Museum

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This paper describes a partnership between the professors of elementary science education and the college's hands-on science museum director. The goals of this partnership are to provide authentic ways of learning and teaching science for pre-service elementary majors at a state university, and to create opportunities for students and their families to develop understandings of science concepts in a community setting. Since 1996, approximately 1000 elementary majors have prepared and reflected on a tabletop science activity presented to Saturday visitors to the museum. Using observations and reflections, this partnership confirms a high level of satisfaction in teaching and learning science for both the pre-service teachers and students with their families in the community museum.

Community science resources including botanical gardens, zoos and science museums are increasingly used by teachers for professional growth, and to enhance out of class learning opportunities for students. Melber (2003) reported significant differences in elementary children's attitudes towards science and scientific content knowledge after participating in a museum-school partnership program. Other studies have stressed the importance of staffing science stations to facilitate dialogue and sustain participant motivation (Allen, 2004; Bowker, 2002; Rahm, 2004; Silberman, Trautmann & Merkel, 2004; Winters, 2004). One study (Pedretti, 2004) reported using science museums as mechanisms to teach the public about science-societal issues and advances in technology.

In the scientific world, keen observations of natural phenomena are fundamental predecessors to the formulation of hypotheses and understandings. Stemming from this reality of how real scientific questions are most often generated, the National Science Education Standards (NRC, 1996) stress the importance of teaching science through an

inquiry based model. For similar reasons, it is vital that undergraduates preparing to become elementary school teachers are provided opportunities to observe and listen closely to children as children struggle to understand science concepts. A central role of the science teacher is to set up experiences that are likely to generate questions and then assist the learners in developing methods to investigate solutions (e.g., NSTA, 2005). Listening to and interpreting the ideas of children is a key part to successful science teaching.

Kindergarten through grade six classroom practicum experiences connected with college courses and student teaching are valuable science teaching opportunities. In many cases, these experiences do not provide the chance for the developing teachers to acutely observe and listen closely as individual students experience the thrill of scientific discovery and formulate conceptual understandings. This may be because of the fast paced realities of learning to teach in a multidisciplinary elementary classroom. One study (Spector & Strong, 2001) however, indicated that "the culture of elementary science methods students was the antithesis of the culture of

science” and another (VanZee, Lay & Roberts, 2003) described the challenges of creating an inquiry based elementary science program, partly because of the didactic science learning experiences of most elementary teachers. Findings like these emphasize the importance of developing ways to incorporate learning experiences where preservice elementary science students have the opportunity to focus on the thoughts and ideas of individual students as they express their scientific understandings.

One way of providing opportunities for preservice teachers to closely observe and actively participate in the learning and the teaching of science to children is to require them to present science activities they have developed in public forums, such as science museums or similar science programs, where the public is invited to actively participate in discovering science. Research (Middlebrooks, 1999; Paris, Yambor & Packard, 1998) has shown that extracurricular partnerships between preservice elementary teachers and public school children increases all participants’ science attitudes and content knowledge.

This report builds on this research and describes the processes and outcomes of an authentic program, in which undergraduates majoring in elementary education develop a science activity and present it to the public on Saturdays in the college’s hands-on science museum.

The Setting and the Activity Development Process

Each semester between 75 and 100 elementary education candidates rise to the challenge of teaching science to children through real world experience at the state university's Science Discovery Center. The remarkable hands-on-science museum has over 75 science displays that invite curious minds of all ages to explore and discover the

fascinating theories and principles governing the physical world.

In a partnership between a retired professor of physics who established and is the director of the facility, and the professors of the elementary science methods courses, all the elementary education candidates enrolled in the science methods courses prepare, present to the public, and reflect on a table-top science activity designed to stimulate the minds of science enthusiasts who come to visit the center on Saturday afternoons. In the past 2-years alone, 348 elementary teacher candidates have each presented their table-top activities to about 1,200 Saturday visitors, one or two at a time. See Figure 1.



Figure 1. *This second grader is guided through an increasingly challenging series of air pressure activities. Through concrete interactions with familiar objects, the goal is to help the child understand initial concepts and then apply those ideas in formulating his own explanations.*

The elementary education program at SUNY College at Oneonta, graduating over two hundred new teachers annually is large by any standard. Finding opportunities for the teacher candidates to have rich experiences in science and science teaching, particularly under the close supervision of

university science faculty is a challenging proposition. Saturday presentations at the Science Discovery Center have enabled university faculty the opportunity to assist the candidates as they attempt the challenging task of learning scientific concepts and then developing a model from simple, common materials effective in teaching the concepts to children.

One main goal of the program is to provide the elementary teacher candidates with the opportunity to learn fundamental science principles through active discovery often involving the construction and manipulation of common materials similar to those they are likely to have in a typical elementary classroom. A further goal of the program is to help the candidates become confident in their ability to teach science to children. One proven effective way of achieving these goals is by supporting the candidates through one-on-one mentoring as they attempt to understand the scientific explanations for common science experiences, and then guiding them as they design, develop, and construct an effective model and presentation technique useful in helping children understand the concept at an appropriate level of comprehension.

Helping the Elementary Teachers Get Ready

Early in the semester, each section of about twenty-five elementary teacher candidates walks across campus for their first exploratory visit of the Science Discovery Center. The students spend about thirty minutes exploring any number of the more than seventy-five hands-on and minds-on displays set up in the facility. After this initial chance to become familiar with the facility each student signs up for two individual meetings with the Center's Director, an experienced and sympathetic physics teacher. The students are asked to come to the first meeting with several ideas

for a tabletop activity. During the first meeting, which usually lasts about twenty minutes, he helps each student select a suitable activity. Together they further develop the idea by his questioning the students in a way that will cause them to consider and re-examine the scientific explanations they offer in support of the activity. For example, a student planning a station on static electricity would be asked to use knowledge of basic atomic structure and explain how static charges occur. During the second meeting, the students take him through the activity they have designed. He again helps the students understand the supporting concepts by asking probing questions and making suggestions concerning the most effective use of their materials.

A significant feature of his role as mentor is that he does not evaluate the students. They feel free to talk candidly with him about their lack of understanding and frequently receive an on-the-spot tutorial about what they need to know. The goal is that all the students can present the activity in a way that will necessitate active mental participation on the part of the visitors, and that they can provide supportive scientific commentary to any visitor, pre-K through senior citizen, when needed.

Time to Teach

Saturday afternoons are show time. The teacher candidates, usually about fifteen each Saturday, are seated at their individual small tables with their prepared activities lining the perimeter of the Science Discovery Center. The science education faculty is present to observe the teacher candidates interact with the visitors, and to offer support, encouragement, constructive feedback and evaluative commentary as needed. Advertising in local papers, campus publications and television usually pays off

as a steady stream of visitors come to visit the facility. Most visitors are parents with elementary age children, but others include church groups, home-schoolers and vacationers. The eager expressions and the inviting activities set up by the elementary candidates draw most participants immediately to the table-top stations where they can explore science, under the prepared guidance of the teacher candidates.



Figure 2. *Through closely guided exploration of a moveable pulley system, the children discover science and the pre-service teachers discover the intangible reward of watching young faces glow as the mysterious world of science begins to make sense.*

The range of ideas represented in the activities is limited only by the combined imaginative powers of the center's director and the teacher candidates. Visitors have explored: molecular polarity by observing the effects of liquid soap on mixtures of oil and water; the effects of solutes on the density of water as indicated by the floating and sinking of carrots; many activities with simple circuits, static electricity, magnetism and electromagnetism; others involving surface tension, chemical reactions, and properties of light, gases and sounds. The elementary candidates have gone so far as to construct mirror reflection boxes and parachutes made of varying materials.

Children have been lifted from the floor in a trash bag inflated with a hair dryer, and others have learned about the insulative properties of whale blubber by putting one hand in a rubber glove which is inserted into a plastic bagful of shortening and then immersing both hands in icy-water. Over the years, hundreds of tabletop activities have been prepared and many more are sure to follow.

Assessments and Reflections

The teacher candidates are evaluated on several measures. They are required to develop a lesson plan for the activity that demonstrates their content preparedness. Additionally, the lesson plan needs to provide evidence that they have anticipated conceptual difficulties likely encountered by the visitors and have a follow-up plan, usually an extension activity or a modification in the presentation, to help further convey the concept supporting the phenomena observed in the table-top activity. The candidates are also required to search for and have available a trade book that they can share with learners interested in learning more about the activity through on-the-spot or home reading.

In addition to the first-hand observations made by the faculty on candidates as they interact and probe the minds of the visitors, the document most useful in evaluating the project's effectiveness on the candidates' readiness to teach science is a reflective commentary the candidates write within a few days of participating in the Saturday session. The teacher candidates are given no specific instructions in how to prepare the reflective piece. The one-to-two page reflective papers written by the elementary teacher candidates speak strongly to the effectiveness of the activity in preparing them to be elementary teachers of science.

Almost all the candidates' reflective comments describe how the project was one of the most meaningful science content and science teaching learning experiences they have ever encountered. The teacher candidates understand that they had to know the content well enough to present it in a way that would evoke questions from the participants and then lead them to self-discovery, not by supplying answers but by asking appropriately targeted questions. The candidates quickly learn that good teaching is not just about talking; it's mostly about listening, observing and being capable of diagnostically deciphering the depth and breadth of a learner's knowledge, and then knowing how to respond to the data in a way that will help the learner discover more fully the ideas and concepts supporting their observations. There is consistent and strong evidence in the reflections that the candidates learn science content, but they also learn a whole lot more. Comments like the following reveal that the teacher candidates learn to be confident in their ability to learn and teach demanding science concepts to children. Summaries of comments are shown in Table 1.

When I first heard about this in class I was really scared. Science is my weakest area and I am really apprehensive about teaching science. [The director] was great. He helped me learn the science. I felt confident in my ability to teach. I was excited to see the first visitors come into the Discovery Center and I was really surprised by how much science many of the kids know. Some were able to tell me how they learned this kind of

thing in school. Others ran off to get their friends and brought them over to my station. It was great to see how much they enjoyed learning through hands-on science.

Follow up interviews with recent graduates of the program provide evidence that the experience had lasting effects on their teacher preparation. Comments such as the following speak strongly to the successes of the partnership.

My experience at the Discovery Center has helped me to set up the centers in my second grade classroom. I make it a very hands-on, discovery based time for my students to explore science and the Science Discovery Center was extremely important in the learning process because it gave us practice in adapting our informal lesson for a variety of different age ranges and levels of learners...I got to see the excitement and enthusiasm of the children when they saw how the experiment really worked.

Most importantly, many of the teacher candidates experienced for the first time the intangible rewards of watching a child's face light up when previously mysterious science phenomena begins to make actual sense.

The teacher candidates are not the only ones benefiting from the project. Their presence in the Discovery Center on Saturday afternoons draws many more visitors than usual to the center. Additionally, many of the teacher candidates schedule class trips to the facility after they obtain their teaching positions.

Table 1. Categories and examples of comments identified from a sample of reflections supporting the effect of the program on the preservice teachers' science teacher preparation.

Categories of Comments	Types of Evidence Found in Teachers' Reflections
Learning science content	<ul style="list-style-type: none"> • All explained the science supporting their activity. • Most had multiple ways of demonstrating the concept. • Many expressed that they were anxious about having to teach science and that motivated them to know the content and anticipate questions and problems. • Most expressed that the conferences with the museum director helped them learn the content.
Learning how to teach science	<ul style="list-style-type: none"> • "I learned that kids are excited about learning with hands-on materials" • "...it made me realize that I need to be able to explain things to children at their level." • "...children used their prior knowledge to formulate an explanation for why the bubbles got bigger.." • "I need to think more carefully about what I am going to say to children to help them understand"; • "...experience helped me learn how to talk about science to children" • "I learned a lot about myself from this experience. I never enjoyed science as a child and that dislike spread into high school. Now that I have been exposed to many different strategies for teaching science concepts I have grown to enjoy science." • "One thing I found interesting is the preconceived notions of the children of what a chemical reaction is." • Many college students expressed how they would do the activity differently in their classroom.
Expressions of high levels of motivation and excitement about learning how to teach science to children	<ul style="list-style-type: none"> • "...most enjoyable out of class assignment"; • "...most rewarding experience of the course" • "...great to see the facial expressions when they figured out how it actually works" • "I have found a new love for science and I hope my enthusiasm spreads through to my students." • "This experience allowed me to see first hand the enthusiasm children have for science."



Figure 3. This first grader explores light by observing and describing how colors look different when viewed with the naked eye and then through a light filter, made from ketchup bottles and colored water.

The Science Discovery Center at our university is notably a unique facility and the opportunities it provides to teach, to learn, and to learn about teaching science cannot be underestimated. It is, however, not the facility alone that makes the project work, but the combined energies of its director, the science education faculty and the teacher candidates who are all committed to bringing the best hands-on science to all those who can be rounded up on Saturdays.

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