Designing and Implementing an Elementary Science After School Field Experience

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Abstract

Field experiences provide an important opportunity for preservice teachers to observe and practice science instruction. Too often, insufficient time is allotted for elementary science instruction in the formal classroom. This paper outlines the opportunities and lessons learned from an after school field experience where preservice elementary teachers worked in two-person teams with a classroom mentor teacher at local elementary schools and community centers to deliver two science lessons per week during an elementary science methods course. Multiple evidences of success are presented at the student and also at the preservice teacher levels. And finally, the important lessons learned include the characteristics of the after-school site, the "instructional" setting, the availability and storage of materials, the co-teacher preservice teams, and the presence and training of the mentor teacher.

Introduction

Field experiences provide future teachers valuable time to observe and practice the art of teaching. They can occur in schools with informal relationships between schools and universities or through formal relationships such as professional development schools (Darling-Hammond, 1994; Teitel, 2000). Unfortunately, time to observe and practice the art of science teaching has become limited as elementary classrooms are prioritizing reading and mathematics over science since these subjects are being evaluated through standardized testing (Kelly, 2000; Leuhmann, 2007; Windschitl, 2002). In response, universities have begun to look toward more after school science instruction time where preservice teachers (PSTs) are free of some of the constraints that exist in the traditional classroom that can include lack of science time, managing large groups of students, standardized testing, and social pressure to teach in didactic ways (Calabrese Barton, 2000; Luehmann, 2007). Previous research has shown that utilizing these after school settings with a science methods course can positively impact preservice teachers' abilities to teach science during student teaching (Cartwright, 2012). In this paper, I describe an after school field experience set within an elementary science methods course as an alternative strategy to provide important teaching experiences for our preservice elementary teachers in science instruction.

Elementary educators routinely report that they feel inadequately prepared to teach science when they enter the teaching field (Riedinger, Marbach-Ad, McGinnis, & Hestness, 2011). Teachers who lack confidence in teaching science utilize a variety of strategies to simplify their science instruction, such as teaching as little science as possible, or relying heavily on textbooks, kits and worksheets (Harlen & Holroyd, 1999). Many teachers appear to have difficulty facilitating science learning through inquiry-based investigations (Chiapetta & Adams, 2000; Marx, Blumenfield, Krajcik, Blunk, Crawford, & Meyer, 1994; Minstrell & van Zee, 2000). Some elementary teachers avoid teaching science (Appleton, 2007) or teach through expository methodologies that compromise students' abilities to develop scientific literacy and an interest in science (Harlen & Holroyd, 1999). Yet, the performance expectations specified in the Next Generation Science Standards emphasize the need to engage students utilizing the practices of science and engineering (NGSS Lead States, 2013).

Equipping PSTs to meet these demanding performance expectations will be challenging with limited formal clinical experiences in classrooms where science is rarely taught. Researchers have demonstrated that teaching experiences should be positioned within meaningful contexts (Borko & Putnam, 1996). These contexts include learning about the content of science in ways that are aligned with how they will be expected to teach, while also aligned with opportunities to practice instructional strategies and ideas that are meaningful (Magnusson, Krajcik, & Borko, 1999). Inquiry-based science instruction may not be observed in the classrooms that PSTs are placed for their field experiences (Bhattacharyya, Volk, & Lumpe, 2009). Although PSTs may have been taught in their methods course to use an inquiry approach, they may find little support or mentoring for it while student teaching (Bhattacharyya, et al., 2009). Additionally, the clinical experiences associated with elementary science methods typically involve more time observing science lessons rather than leading the instruction themselves. Meeting the pedagogical demands of reformed instruction can be challenging because teacher preparation programs cannot dedicate a sufficient amount of time preparing and modeling reform-based science instruction.

With limited opportunities to lead science instruction through first-hand experiences, methods course instructors may consider field experiences that do not occur in a school during the school day, like after school or museum settings. The after school setting has been shown to be a place where PSTs can develop their science teaching identities to support a constructivist teaching approach (Wallace & Brooks, 2014). PSTs who participated in after school teaching experiences with their science methods course improved their beliefs about their ability to be effective science teachers of diverse students (Cone, 2012). After receiving initial support from a grant from the National Science Foundation (NSF), an after school field experience was piloted and implemented over 2.5 years with 57 PSTs. The objectives of this article are the following:

- Describe the program so that other universities may consider providing this teaching experience for their PSTs,
- Provide detailed assessment of impact of the course on the elementary students' content knowledge and PSTs willingness to facilitate inquiry, and

- Outline current research efforts on long-term evaluation of impact on PSTs who are now teaching in their own classrooms.

Course Design

Course setup and strategies.

The three credit hour elementary science methods course met over a 15 week semester. The two unique aspects of this methods course included 1) a sponsorship from the NSF to provide stipends ($800) to the 57 PSTs for additional evaluation data to be collected and 2) a weekly two-lesson after school field experience that occurred over 8 weeks. This NSF-sponsorship was in place for 2.5 years for a total of 5 semesters. During this time the methods course enrollment with a traditional field experience was typically 22 students each semester. Typically, 75% of these students agreed to participate in the research program for a total of 118 participants in the traditional field experience. The methods course with the after school field experience had a lower enrollment each semester (about 10-15) which resulted in a total of 57 participants in the after school field experience. This lower enrollment was due to the scheduling conflicts that exist for many PSTs who unavailable during the after school hours.

The college course exposed PSTs to reform-based science teaching strategies, and then as co-teacher teams working in PST teams of 2, they practiced these teaching strategies in a weekly non-traditional after school learning space. The strategies employed are based on scientific and engineering practices delineated by the Next Generation Science Standards (2013):

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Additionally, the Next Generation Science Standards specify that “engagement in practices is language intensive and requires students to participate in classroom science discourse” (p. 389, NRC, 2011). The role of “discourse” was a key feature of the program as well as the acronym for the grant program itself which was SCI-TALKS (Supporting Community Initiatives in Teaching, Learning and Knowing Science). The role of scientific and engineering practices along with student discourse were targeted components of the program as these are often overlooked due to lack of time for science instruction during the regular school day.

The methods course was developed to help the PSTs understand themselves as science learners and teachers, design units that would engage students in guided-inquiry, and then have the space and community to reflect on their practice after actually teaching science in an after school classroom. For this study, guided-inquiry focused on the third-level of inquiry where an investigation question is provided by the teacher but the procedures and conclusions are not (Bell, Smetana, & Binns, 2005). At the beginning and again at the end of the semester, PSTs wrote a self-reflective autobiography of their feelings and experiences in science teaching and learning (Koch, 2012). These "science autobiography" prompts can be found in Appendix A. These reflections are a powerful reflective learning experience for the PSTs as they began to analyze the type of science instruction that had long-term meaning and impact on their own lives (Koch, 2012). Derived from the *National Board for Professional Teaching Standards*, PSTs wrote another more extensive "written commentary" which was a guided reflection on one of the science and math lesson that they wrote for their science unit. The assignment directions and rubric for this "written commentary" can be found in Appendix B. This methods course was designed to help PSTs confront their negative perceptions of science and move toward a more positive attitude with actual instructional experiences that most regular methods students do not have.

PSTs were also required to read and react to readings from *Science and Children*, the National Science Teachers Association magazine for elementary teachers, and *Picture Perfect Science* to help them refine their practice and further understand the successes, challenges, and barriers they were facing as beginning teachers of science. A list of these readings can be found in Table 1. The majority of the science lessons that I taught in the methods course and also provided the PSTs to teach in the after school program were derived from field-tested and research-supported learning programs like Full Option Science System (FOSS) and *Picture-Perfect Science* (Ansberry & Morgan, 2010) that facilitate student learning through guided-inquiry. These curriculum programs were chosen because of the lack of experience and confidence that PSTs have in teaching science and science content particularly. These activities in the classroom focused on NGSS' scientific and engineering practices, particularly, planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, and obtaining, evaluation and communicating information. As lessons were either taught by the professor or through peer-teaching, focus was placed on identifying the key practices of each lesson.

Table 1 (Click image to enlarge)

Assigned Readings for Each Week

Week #	Reading 1	Reading 2
2	Zangori, L., Forbes, C., & Biggers, M. (2012). This Is Inquiry... Right?. *Science and Children, 50*(1), 48-53.	
3	Jensen, J. & Kindem, C. (2011). Step Up into Full Inquiry. *Science and Children, 48*(9), 48-53.	Powell, D, Needham, D., & Aram, R. (2008). Connecting Children to Their World. *Science and Children, 46*(4), 40-46.
4	Chapter 3 Teaching Science Through Inquiry Ansberry, K. R., & Morgan, E. R. 1. (2010). *Picture-perfect science lessons – Expanded 2nd Edition: Using children's books to guide inquiry, 3-6*. Arlington, Va.: NSTA Press.	Hershberger, K., C. Zembal-Saul, and M.L. Starr. (2006). Evidence Helps the KWL Get a KLEW. *Science and Children,* 43(5), 50–53.
5	Chapter 4 5E Instructional Model Ansberry, K. R., & Morgan, E. R. 1. (2010). *Picture-perfect science lessons – Expanded 2nd Edition: Using children's books to guide inquiry, 3-6*. Arlington, Va.: NSTA Press.	Rommel-Esham, K. (2007). How Much Popcorn will our Classroom Hold. *Science and Children,* 45(2), 22-27.
6	Chapter 5 Connecting to the Standards Ansberry, K. R., & Morgan, E. R. 1. (2010). *Picture-perfect science lessons – Expanded 2nd Edition: Using children's books to guide inquiry, 3-6*. Arlington, Va.: NSTA Press.	Willard, T., Pratt, H., & Workosky, C. (2012). Exploring the New Standards. *Science and Children*, 50(2), 13-17.
7	Everett, S., & Moyer, R. (2009). Methods and Strategies: Literacy in the Learning Cycle. *Science and Children,* 47(2), 48-52.	Zales, C.R. & Unger, C. S. (2008). The Science and the Literacy Framework. *Science and Children*, 46(3), 42-45.
9	Doto, J., & Golbeck, S. (2007). Making "Photo" Graphs. *Science and Children*, 45(2), 33-35.	Cavallo, A. (2005). Cycling Through Plants. *Science and Children*, 42(7), 22-27.
10	McCullar, H. (2015). Am I really Teaching Engineering to Elem Students? *Science and Children*, 52(7), 65-70.	Milano, M. (2013). Guest Editorial: The Next Generation Science Standards and Engineering for Young Learners: Beyond Bridges and Egg Drops. *Science and Children*, 51(2), 45-47.
11	Gilbert, J., & Kotelman, M. (2005). Five Good Reasons to Use Science Notebooks. *Science and Children,* 43(3), 28-32.	Lottero-Perdue, P.S., Lovelidge, S., & Bowling, E. (2010). Engineering for All. *Science and Children,* 47(7), 24-27.

Including after school time for teaching may sound trivial, but it can be challenging with different class and work schedules of so many PSTs. For the grant supported program, I chose to conduct a preliminary "interview" with each PST to make sure they were willing to participate in the research study and that they were available during at least two after school sessions (either a Monday and Wednesday or a Tuesday and Thursday). To form a supportive co-teaching two-person PST team, I paired two PSTs who were available on the same days for this after school sessions which were 60 minutes in length. The methods course then met for 75 minutes twice a week during another time slot.

Figure 1 (Click image to enlarge). Description and timeline of course activities.

Figure 1 contains a timeline with description of the various aspects of the program including the responsibilities of the professor coordinating the activities, the PSTs, and the methods course. Identifying and coordinating suitable after school partners in the community was the first and foremost task that had to be accomplished before sending PSTs out into the community.

Site selection.

I met with various school and community-based after school programs to identify which would be supportive and suitable as a site. The selection of the after school site and the physical teaching space was found to be perhaps the most critical aspect of the success of this program. The sites needed to have an appropriate number (8-20) of students in grades 3-5 that the PSTs could teach. The site needed to contain a suitable learning space with minimal distractions and sufficient acoustics that the PSTs could easily be heard. I quickly learned that a gymnasium was a challenging learning space because of the difficult acoustics and propensity of distractions. Even a traditional classroom must be carefully selected because the regular classroom teacher must give their permission for the room to be used even when they might not be there. Ideally, the classroom teacher agrees to stay after school to be the mentor teacher so that they are there to oversee the usage of their room. The mentor teacher was a classroom teacher who agreed to be available at the after school site during the after school science lessons. They received a small stipend ($25/hour) for their time. They were usually identified by the site and ideally knew the students so that they could assist the PSTs with classroom management issues. They provided an extra set of hands and immediate feedback on the quality of the lesson.

The sites used each semester depended upon the number of PSTs enrolled in the alternative methods course. I chose to bring the science program to the community through delivery in existing after school childcare programs in high need local areas. Five of the sites were at elementary schools that had after school programs which ranged in free/reduced lunch percentages between 67 to 81% and minority population of 4-47%. Our more urban schools have a significantly higher proportion of African American students (47%), in contrast to the more suburban schools with a very low percentage of minority students (4%), although they still have a high percentage of free/reduced lunch (67%). Two site placements were located at community childcare sites which drew students from the same elementary schools. Because of the diversity of these site locations, the PSTs' experiences were somewhat varied in terms of the number of students in attendance, the space and type of room, and the behavioral expectations in place at each site. On average across the 5 semesters, each site provided 8-18 students for the after school program in grades 3-5. Students typically participated multiple semesters in the after school program with different PSTs each semester.

After school instruction worked best in those settings where students were accustomed to participating in enrichment activities after school. If the students were only accustomed to playing on the playground or in the gymnasium everyday then it was quite challenging (nearly impossible) for them to successfully participate in a productive learning environment. I attempted to bring this after school science program to several low-income after school care programs (such as Boys & Girls Clubs in community centers) to varying degrees of success. If the PST had prior experience with this type of population (e.g. had worked in after school child care), then they understood the challenges of bringing semi-formal instruction to the site and could better manage distracted students. Much college class time was spent on exploring culturally-relevant teaching and conveying the necessity of making our science instruction unlike traditional "boring" science instruction.

Weekly course schedule.

As outlined in Figure 1, the first 3 weeks of the semester focused on preparing the PSTs to enter the classroom with confidence and appropriate teaching and management strategies. These class meetings focused on basic classroom management strategies, classroom safety issues, and the targeted NGSS scientific and engineering practices. General elementary safety concerns were discussed along with the specific concerns that PSTs would face in their upcoming unit of instruction for the after school space. Each class period focused on a particular NGSS scientific and engineering practice to ensure the PSTs were not only able to implement them but also plan lessons they would teach during weeks 10-12 to target them. I made sure that the sites were ready to receive the PSTs. Additionally, I gathered and organized the materials for the after school science instruction which would begin in week 4 of the semester.

During weeks 4-12 of the course, PSTs implemented guided-inquiry science lessons provided by the professor of the methods course twice a week which were derived from FOSS and *Picture-Perfect Science*. These initial lessons served as models of instruction for the PSTs as they wrote their own science unit implemented during weeks 10-12. During weeks 4-9, the lessons that I provided were first peer-taught within the methods course and then implemented at their after school site the following week. Through this process the PSTs viewed each lesson in the college classroom before teaching it. Here, they learned about the science concepts and the science and engineering practices from the NGSS associated with each lesson. They used class time to deepen their own conceptual understanding while simultaneously learning about the appropriate pedagogical content knowledge associated with the science concepts for the week’s activities.

In weeks 10-12, PSTs began implementing their own science unit which they had spent several weeks developing and going through multiple stages of review and revision. The first lesson that the PSTs wrote individually was a science lesson that integrates mathematics. The co-teacher team for the after school program coordinated their lesson plans so that both of their lessons were united by science theme while targeting appropriate scientific practices. The PSTs first draft of the lesson was exchanged strategically with another PST in the room who was not on their teacher team or sat at their table group. Each PST was given a rubric, like the rubric in Appendix C for the science/math lesson, with the addition of a blank row under each criterion row of the rubric. The PSTs were required to make a proficiency claim (indicate which level on the rubric the lesson achieved) and provide evidence to support that score by giving constructive feedback in the blank row under each rubric criterion. This accomplished two goals: 1) PSTs would actually read the rubric and 2) with practice, PSTs would improve their understanding of the rubric to guide them as they would revise/write their own lessons. To stress the importance of this peer review, I gave them a grade on their peer review which was half the value of the lesson plan grade. They would earn 0 points for writing “great” as constructive feedback. I challenged them to provide me evidence that they actually read their peer’s lesson plan. At the start of the next class, the PSTs were given time to discuss their peer reviews with the lesson writer. PSTs then had until the next class period to submit another revised lesson plan to me. If my grade on their lesson plan was below a "B", they were required to continue to make revisions until the lesson plan was suitable to be taught in the classroom.

PSTs were free to modify existing FOSS or *Picture Perfect Science* lessons or create them on their own. Modifications were necessary, particularly for the FOSS lessons, because the lessons must follow the 5E learning cycle (Bybee, Taylor, Gardner, Van Scotter, Powell, Westbrook, & Landes, 2006). The rubric for the Science and Math Lesson can be found in Appendix C. I ensured that the lesson targeted appropriate science concepts and science and engineering practices from the NGSS. PSTs implemented the science unit that they developed with their co-teaching team at their after school site in weeks 10-12. PSTs included the following lessons in their five-lesson science unit which were graded by a similar rubric found in Appendix C: two lessons integrating math and science, one with reading/language arts, one that utilized technology, and one that connected with the local community either through a guest speaker or virtual experience.

The final three weeks of the semester (weeks 13-15) focused on reflections and analysis of embedded student assessment data. I provided feedback on their unit of instruction including further suggestions for revision and improvement. PSTs wrote an extensive 6-8 page reflection called the written commentary (described in Appendix B) that was modeled after the National Board for Professional Teaching Standards Middle Childhood Generalist Portfolio where they analyzed their math and science lesson from their unit. Finally, PSTs presented a completed unit plan with their 5 lessons and an overview of their units to their peers that included a PST selected video clip of their math and science lesson from their after school instruction experience.

Evidence of Success: The After School Students

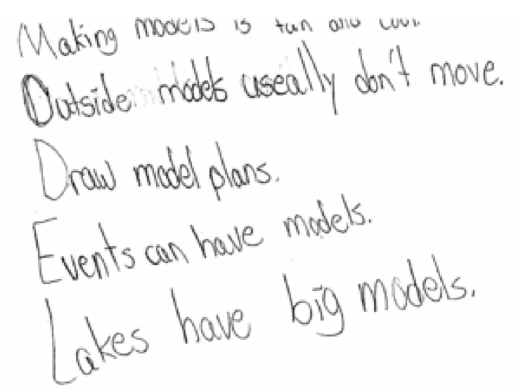
Evidence of success for this type of field experience was obtained both from the PSTs' experience as well as the elementary students' experience. Both populations benefit as the PSTs gain experience and confidence in teaching science and the elementary student experiences guided-inquiry science lessons that they may not experience during the normal school day. With the support of the grant's external evaluators and NSF funding, all our PSTs administered several embedded assessments during the after school program. These embedded assessments provide insight into the change in elementary students' understanding over the course of the field experience while also modeling innovative methods to measure student knowledge.

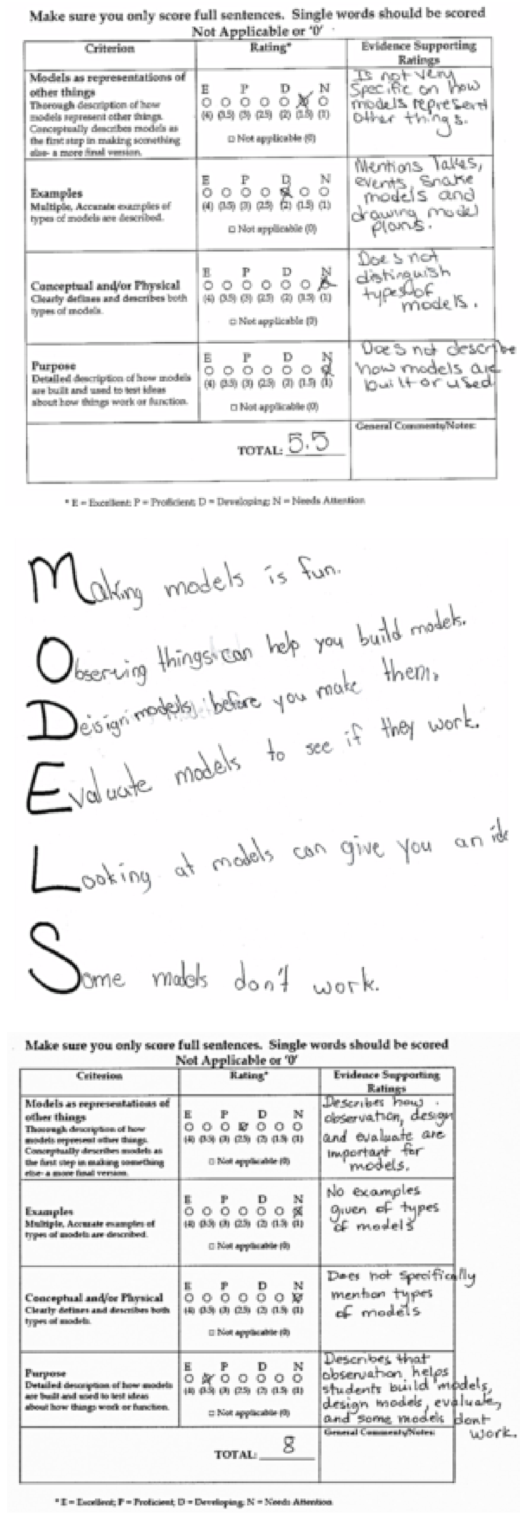
For a more detailed view into the assessments, one semester lessons that were derived from the FOSS Unit, Models & Designs, can be more closely examined. Modifications were made to explicitly target scientific and engineering practices as well as to make it align with the 5E learning cycle (Bybee et al., 2006). This science unit contains four investigations that engage students in the process of engineering design and construction which particularly targets the

NGSS scientific and engineering practice of “developing and using models.” Students learn about models and how they can be used to enhance understanding while they simultaneously engage in the design process that requires refinement of the models to improve the design. To evaluate changes in students’ conceptual understanding about models, an acrostic embedded assessment was used, called “first-word last-word” which was adapted from Keeley (2008). Students wrote the word “MODELS” in a vertical column on the left side of a page. Students were then challenged to write a sentence or a complete thought about models that begins with each of the letters of the word “MODELS.”

Figure 2 shows one of the student’s pre and post First Word/Last Word assessment to illustrate this assessment technique. PSTs used a rubric (Figure 3) which was developed by the external evaluators and myself to evaluate student responses. Each semester we developed a different rubric for a different science unit because students often participated in the after school program multiple semesters. Different aspects of models were examined with the rubric which included the following: models as representation of real things, examples of uses of models, recognizing that models can be conceptual and/or physical, and identifying the purpose of models. Across all the after school sites, there were statistically significant differences (t=3.6, p<.01) between First Word and Last Words. However, this was a challenging assessment to administer with fidelity across sites because many of the PSTs acknowledged that they did not follow the instructions by asking for and requiring complete sentences. Asking students to write (particularly complete sentences) in the after school learning space was problematic. Nonetheless, these types of assessments served as models for alternative embedded assessments that many PSTs continued to utilize in their teaching experiences.

Figure 2 (Click on image to enlarge). Initial First-Word assessment to describe “models” (top left). End of unit Last-Word assessment (bottom left). PSTs analysis using the rubric in Figure 3 are shown in right panels.





Make sure you only score full sentences. Single words should be scored Not Applicable or '0'

Criterion	Rating*	Evidence Supporting Ratings
Models as representations of other things Thorough description of how models represent other things. Conceptually describes models as the first step in making something else- a more final version.	E P D N (4) (3.5) (3) (2.5) (2) (1.5) (1) □ Not applicable (0)	Is not very Specific on how models represent other things.
Examples Multiple, Accurate examples of types of models are described.	E P D N (4) (3.5) (3) (2.5) (2) (1.5) (1) □ Not applicable (0)	Mentions Talks, events, Snake models and drawing model plans.
Conceptual and/or Physical Clearly defines and describes both types of models.	E P D N (4) (3.5) (3) (2.5) (2) (1.5) (1) □ Not applicable (0)	Does not distinguish types of models.
Purpose Detailed description of how models are built and used to test ideas about how things work or function.	E P D N (4) (3.5) (3) (2.5) (2) (1.5) (1) □ Not applicable (0)	Does not describe how models are built or used
	TOTAL: 5.5	General Comments/Notes:

* E = Excellent; P = Proficient; D = Developing; N = Needs Attention

Making models is fun.
Observing things can help you build models.
Desigin models before you make them.
Evaluate models to see if they work.
Looking at models can give you an ide
Some models don't work.

Make sure you only score full sentences. Single words should be scored Not Applicable or '0'

Criterion	Rating*	Evidence Supporting Ratings
Models as representations of other things Thorough description of how models represent other things. Conceptually describes models as the first step in making something else- a more final version.	E P D N (4) (3.5) (3) (2.5) (2) (1.5) (1) □ Not applicable (0)	Describes how observation, design and evaluate are important for models.
Examples Multiple, Accurate examples of types of models are described.	E P D N (4) (3.5) (3) (2.5) (2) (1.5) (1) □ Not applicable (0)	No examples given of types of models
Conceptual and/or Physical Clearly defines and describes both types of models.	E P D N (4) (3.5) (3) (2.5) (2) (1.5) (1) □ Not applicable (0)	Does not specifically mention types of models
Purpose Detailed description of how models are built and used to test ideas about how things work or function.	E P D N (4) (3.5) (3) (2.5) (2) (1.5) (1) □ Not applicable (0)	Describes that observation helps students build models, design models, evaluate, and some models dont work.
	TOTAL: 8	General Comments/Notes:

* E = Excellent; P = Proficient; D = Developing; N = Needs Attention

Figure 3 (Click on image to enlarge). First Word/Last Word assessment (example provided in Figure 2) rubric.

Rubric for Assessing First Word/Last Word – "Model"

	Excellent	Proficient	Developing	Needs Attention
Models as representations of real things	Thorough description of how models represent other things. Conceptually describes models as the first step in making something else- a more final version.	Accurate description for how a model looks like something else. Does not indicate that models are used as part of a bigger process of testing and building.	Vague or incomplete description of how models look like other things. Description does not apply to all types of models.	None of the sentences indicates that models are used to represent other things.
	Excellent	**Proficient**	**Developing**	**Needs Attention**
Examples of Use	Multiple, Accurate examples of types of models are described. Includes examples of both physical and conceptual models.	Several examples of models are described; not all are relevant to engineering (ie…fashion, art are technically correct in terms of definition).	Vague or incomplete example listed. Examples do not clearly imply who uses them or what they are used for.	None of the sentences mentions an example of a model.
	Excellent	**Proficient**	**Developing**	**Needs Attention**
Conceptual &/or Physical	Clearly describes the difference between conceptual and physical models by defining both types of models and uses in detail.	Accurately describes conceptual and physical models but description lacks detail.	Defines one type or the other but does not include both.	None of the sentences provides any reference to conceptual or physical models.
	Excellent	**Proficient**	**Developing**	**Needs Attention**
Purpose	Detailed description of how models are built and used to test ideas about how things work or function.	Accurate description of how models are built to describe how something will look; does not include description of how things work or function.	Basic description of using models but does not clearly describe purpose.	None of the sentences describes models as having purpose or use in problem solving.

Learning from Mistakes: PSTs growth

During the first part of the after school field experience, PSTs implemented the FOSS Models & Designs lessons and the aforementioned embedded assessments which included the targeted NGSS scientific and engineering practices of planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, and obtaining, evaluation and communicating information. They then implemented their own 5 lesson science unit created with their co-teaching team which built upon these ideas of models and design which were required to include the NGSS practices. To gain better insight into the program and the PSTs experience, one PST, Kirsten, will serve as an example to illustrate the power of this experience for those elementary educators who are "science hesitant." Kirsten was a traditional elementary education student who did not feel particularly confident in teaching science. I chose to include her comments because she spoke with me several times about her lessons in an effort to prepare the best possible lesson for her students. This was not always the case as most students chose to develop their lessons independently. Her experiences illustrate a powerful learning opportunity when teaching experiences do not go as well as planned. Longitudinal comments from other participants are presented in the Lessons Learned section of the paper.

In her written commentary (described in Appendix B) where she described the effectiveness of the lesson, Kirsten explains the lessons that she and her co-teacher team devised for their unit:

> Prior to my lesson were our other transportation lessons that went along with our unit, including a lesson on asphalt, or the materials that help to make a road, and a lesson investigating the different forms of transportation one can take. After my lesson, another math and science lesson was taught on different modes of transportation as well. My video shows students working cooperatively in groups of three to explore the greenhouse effect.

PSTs were challenged this semester to continue the idea related to engineering and models (as discussed previously) into their own units of instruction that were implemented during weeks 10-12 of the semester. Kirsten's team developed a set of lessons related to transportation engineering. One of the lessons included an expert visitor, a transportation engineer, to come and speak with the students. Kirsten's lesson targeted the environmental impacts of transportation and the burning of fossil fuels which contribute to the greenhouse effect. She selected the classic Alka-Seltzer tablet lab to do with her students where two Alka-Seltzer tablets are placed inside a 2-liter bottle to release carbon dioxide. Two bottles with temperature sensors (one with the extra carbon dioxide and one with normal air/water as the control) are then placed under a light where the temperature is monitored over several minutes. Before she did this with her students, we discussed the challenges with this lab because it seldom finishes in a timely manner with the expected results. She said she practiced it at home and was able to do it successfully.

Kirsten describes her feeling about the effectiveness of the lesson in her written commentary. She writes, "The lesson investigation did not work out as planned… the classic greenhouse gas experiment with Alka-Seltzer tablets is problematic and seldom works as planned." She recognized the challenges associated with this lab. The warning that I provided her helped her to remain calm because she had already thought about possible explanations she would provide students. She outlines her thoughts for revising the lesson below:

> My first revision for this lesson would have to be concerning the second experiment involving the carbon dioxide. Time-wise, it made it impossible to finish my lesson in the sixty minutes I was given. I did not think recording the temperatures for ten minutes, for a total of twenty minutes with both experiments, would be as time consuming as it was. Second, the experiment with carbon dioxide did not give us the desired results, and although we discussed our possible errors in our experiment, successful results would have been better for the students.

Although successful results are always preferred and definitely feel better in the moment, teachers oftentimes remember those experiences that do not work for a longer time. These experiences provide opportunities to grow as an educator and to frame our thinking about the next time we will tackle that investigation. Kirsten echoes these thoughts below:

> The knowledge I have gained from this lesson will certainly impact my future instruction in a positive manner. I am glad that everything in my lesson did not go perfect because it allowed for reflection and improvement. I greatly enjoyed working with my students and I can only hope that they got as much out of Sci-Talks [the after school program] as I did.

Kirsten tackled one of the most challenging investigations of her team's unit and recognized that it did not go as well as she had hoped. However, she gained much from the experience and recognized the importance of the students investigating something first-hand. She wrote the following in her reflection as she began to plan her lessons for her unit, "I noted that in prior Sci-Talks lessons with the FOSS kits, students were always more excited to get their hands on something and develop an answer to a question in that manner."

Lessons Learned for Implementation

After coordinating this program across two different communities and universities, several important lessons were learned which could make replication of this program easier in other areas. The next section describes the important characteristics of the after school site, the "instructional" setting, storage of materials, co-teacher preservice teams, and the mentor teacher.

The PSTs lack of experience teaching, along with low-efficacy in science instruction particularly, necessitated that I find the most favorable teaching setting to maximize the likelihood of their success which was also the reason that I provided examples of very "doable" curricula materials like FOSS and *Picture-Perfect Science.* Several times throughout our program, PSTs became very troubled by their inability to be a "proper teacher" when the challenges were more about the setting (inadequate teaching space with too many distractions) and the children (not accustomed to after school enrichment activities). Therefore, after several semesters, I chose to deliver our program primarily at schools with after school childcare that included other ongoing enrichment activities that often happened at school locations. When the students receive instruction at a school in a classroom, they tend to behave with more appropriate school-like behavior even in the after school hours. Additionally, the preferred sites were those that provided transportation home after the enrichment activities although this was a rarity. As students would be picked up by parents to go home before the end of the lesson, our PSTs were not able to discuss the results from the investigation with everyone and the slow trickle of students leaving for the day would become frustrating to them.

If the after school science program requires the PSTs to teach multiple times over the semester, careful thought should be given about transporting supplies and finding a place to store them on-site and to ensure that they were available during these hours. If PSTs must carry a large box to and from the site each day, this can take up more time and possibly frustrate them even more. Figuring out these seemingly small logistical issues help to ease frustration levels and sources of potential anxiety.

One of the most significant components of the program that the PSTs positively reflect on is the importance of the partnership between themselves and their fellow preservice teacher partner. They highly value the support that they receive from their co-teacher team as they work together to overcome challenges with teaching science and managing a room of students for the first time on their own. One preservice teacher shared the following during her interview conducted while student teaching:

> [The co-teacher team] made [the program] stronger, simply because there was another presence in the room. Just another presence in the room helps tremendously. It helps keep order, helps keep them calm. If I had a few minutes where I had to stop for a computer issue or pass out markers or do this and that… having someone there that we both know what's going on and we know, at this point, we need to pass this out, at this point, we need to have this ready… it helped because one can be teaching and one can be gathering materials and then we swap out at some point and we just trade off of each other and worked off of what we know we were doing. So, I thought it was a tremendous experience.

Another aspect of the program that helped ensure success was the presence of a classroom mentor teacher in the after school learning space. Ideally, the mentor teacher provided their classroom to be the learning space and was familiar with the students participating in the program. Effective mentor teachers provided suggestions on grouping students, intervention when classroom management started to break down, and constructive feedback at the end of the lesson. I provided support to mentors and provided appropriate mentor teacher feedback because their role truly impacted the preservice teacher's self-efficacy and self-perception in teaching. This support included a meeting prior to the start of each semester with each mentor to highlight their desired role as well as ongoing feedback during the semester as program leaders visited each site. Mentor teachers could range between too domineering or distracted and could jeopardize program effectiveness. The PSTs generally found the mentor teachers to be quite helpful because they knew the students well and had much more experience managing a classroom of busy students than the PSTs did.

Longitudinal Impacts on PSTs

The after school field experience program provided the PSTs a valuable opportunity to test out their own lesson plans in a pseudo-classroom space that they managed themselves. Traditional field experiences seldom provide sufficient opportunities for the preservice teacher to feel that they are "in charge" of the learning space. Follow-up interviews conducted during student teaching and their first years in the classroom reveal that nearly all SCI-TALKS students felt this is the single most important contribution of the program. The constructivist approaches implemented in the after school environment to teaching science transferred into their traditional classroom instruction (Cartwright, 2012). PSTs have more positive ideas about science after participating in the after school science experience and are more willing to overcome the barriers that often exist for science teaching during student teaching such as a lack of confidence in teaching science, time for science instruction, and limited resources (Cartwright, Smith & Hallar, 2014).

Currently, longitudinal follow-up research is being conducted with PSTs who are now classroom teachers. This research includes an online questionnaire for all graduates, along with interviews and classroom observations for a convenience sample that are teaching similar grades within a drivable distance to campus. The comments shared about the program that they experienced 2-3 years ago reflect what they have found to be most beneficial and perhaps influential in creating their own instructional spaces. One teacher wrote the following:

> For my science methods course, I participated in Sci-Talks. The experience of teaching real students, real science lessons was amazing. During these lessons, I was asked to not only plan science lessons, but also to implement them. As a result, I was able to see how a real classroom worked. Sometimes, my lessons looked great on paper, but then flopped in the classroom. I was able to take these experiences into my real classroom with me. In addition, during my time in Sci-Talks, I learned along with the students. As a result, in my real classroom I am more willing to take risks and allow students to explore science content.

This student recognized the importance of actually implementing the lessons that they wrote so they could see what would work and what may not. This willingness to “take risks” is an important component for themselves as well as their students (Le Fevre, 2014). Similarly, another teacher wrote the following:

> I believe that this class prepared me as much as possible. Not all of the classes give you that hands on, in the classroom, experience. It was the best teaching experience I had received until I did my student teaching. Because in Sci-Talks, we were the teachers. We gave the lessons and we made the preparations. It was a great experience that prepared me for the real world of teaching.

Preparation for the “real world of teaching” cannot happen in the college classroom. It seldom happens observing someone else teach a science lesson. PSTs need their own teaching experiences as mentioned by another student who said the following in her interview during our longitudinal research in her own classroom, “I would just like to say Sci-Talks is wonderful and just before that I was so nervous and I thought, ‘Oh Lord, how am I going to teach it I can’t even talk’ you know. But, after Sci-Talks I was like, Hey, I can do this I can teach science. Just because it’s my weakest subject, I can teach anything.” Many PSTs perceive science and math as their weakest areas of content. Providing them a safe after school field experience where they themselves are the primary teachers can have long-term impact on their willingness to facilitate guided inquiry instruction in their own classrooms.

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Supplemental Files

Cartwright-Supplemental-Materials.docx

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