# Tackling Science Instruction Through “Science Talks” and Service Learning

**Chapter** · October 2017
DOI: 10.1007/978-3-319-42430-9_12



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# Chapter 12
# Tackling Science Instruction Through "Science Talks" and Service Learning

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**Abstract** Many preservice teachers struggle in science courses and foster anxieties regarding science instruction in their future classrooms. Providing time and support for preservice teachers to teach science in an after-school classroom through service learning allows them to build a science learning environment outside the formal school day. In this alternative learning space, student dialogue can enhance learning in science while also improving preservice teachers' confidence and enthusiasm to teach science. SCI-TALKS, a program that integrates service learning and science methods instruction, fosters a supportive, "safe" environment honoring student and preservice voice through "Science Talks" where students and teachers develop and deepen science understanding collaboratively. Expository teaching strategies compromise students' abilities to develop scientific literacy and interest in science and also contribute toward the anxiety felt by preservice teachers that they need to be an expert in all science content. Collaborative development of science ideas through discussion and "talk" can lead to better understanding and more positive attitudes about science and science instruction. With the constraints of the formal classroom and the anxiety over science content, community-based service-learning teaching opportunities for early education preservice teachers can support both the development and refinement of inquiry instruction skills.

**Keywords** Self-efficacy • Anxiety • Science education • Elementary science education • Early childhood science education • Service learning

*After reading a section of the reader, Katlyn stops and says, "Whoa, did you hear that? Plants can make their own food!"*

"*What?!*" *a girl says.*

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K.L. Heider (ed.), *Service Learning as Pedagogy in Early Childhood Education*, Educating the Young Child 11, DOI 10.1007/978-3-319-42430-9_12

*"Do we make our own food by getting into the sun?" Katlyn asks. "No," a few say.*

*A girl raises her hand and says, "I know how they make food. They get really sunny, and they eat their sweat."*

*Katlyn says she doesn't think that's exactly how it works, but she likes the way she is thinking. Katlyn reads that plants need space. "What does it mean to be too crowded?" Katlyn asks the class.*

*"It means they really can't get space like humans," a boy answers.*

*Katlyn compares it to how people need their space.*

*A boy mentions if there were 100 people in their room they wouldn't have much room.*

*Katlyn asks if the children think the plant in the book has enough space, enough light, enough water. The children answer back, "Yes."*

The scenario above is taken from field notes of a preservice teacher (PST) facilitating a science lesson in the first grade classroom where she is doing her student teaching that occurs in the final semester of her undergraduate preparation program. At the beginning of her science methods course, she described her feelings about science. "Science has rarely been a topic that brings positive thoughts to my head. Thinking about science makes me cringe most of the time because I don't believe that I am 'good' at it." Katlyn is not alone, as many early and primary educators have anxieties regarding both science and science teaching. To combat these challenges, a special section of the science methods course at Katlyn's university replaced the traditional formal clinical "observation" experience with an after-school service learning clinical where PSTs worked in a two-person team to teach 15 science lessons. Katlyn was an actual teacher leading science lessons during her science methods course in after-school time. This service-learning opportunity transformed Katlyn's outlook on teaching science. At the end of the semester, she wrote:

> *Even though I have had some problems with science in the past, the future is looking a little brighter. I have found that the more involved you are in teaching science, the easier it is to feel comfortable teaching it. I still have my doubts about teaching science, but I am further along than I was at the beginning of the semester. I don't know that I feel one hundred percent positive about all of the science lessons I have taught, but it's a step in the right direction.*

For Katlyn, the opportunity to lead science instruction, work with a fellow PST, write and implement science lessons, and deal with classroom and time management issues transformed her feelings about science and science teaching. Her improved confidence in teaching science also spread to other subjects. She wrote, "Not only do I feel more confident to teach a science unit, but also teaching in general. Classroom management has been a large part of the whole experience that I wouldn't have received anywhere else." PSTs face many challenges associated with teaching science that include their own anxieties with science (Bleicher 2007; Kelly 2000) and little prior experiences with science through inquiry instruction (Crawford and Cullin 2004; Justi and Gilbert 2002; Justi and van Driel 2005; Kelly 2000). Non-traditional clinical teaching through service learning provides an opportunity to better prepare future science teachers, particularly at the early education and early elementary levels.

## Key Terminology

This study targeted each of the four essential elements of community-based service learning in one of the science methods courses offered at the university: diversity, academics, service learning, and community service (Eyler and Giles 1999; Wade 1995, 2000). Students were placed in communities of diverse populations to ensure that they were provided an opportunity to engage with students that would challenge their preconceived notions about diversity. Students were supported and required to apply their academic knowledge to further enhance their understanding of concepts and skills taught at the university. Service learning was facilitated through the mutual benefits of the community that would not have received this engaging learning opportunity and also the PSTs themselves as they learned about leading instruction in an actual classroom. This reciprocity further supports the idea of service learning. Finally, community service was targeted and linked to academic learning through the opportunities for PSTs to analyze and reflect on their experiences leading instruction within this community setting. Although the after-school teaching experience was required for all the PSTs in one section of the methods course, another section (which did not require this service learning component) was offered which required a traditional clinical observation experience.

The expectations for today's early education teachers are particularly challenging in the area of science which is often a subject area where preservice teachers lack confidence. The Next Generation Science Standards (NGSS) have increased the rigor and expectations for students' science learning, particularly in the K-2 grades. Although the need for inquiry has been well-established since the release of the National Science Education Standards in 1996, the specificity of the targeted scientific practices and science knowledge in the NGSS emphasize the need to engage students effectively in the primary grades (NRC 1996, 2012). Unfortunately, many teachers have not experienced this type of inquiry-based instruction in their own education (Crawford and Cullin 2004; Justi and Gilbert 2002; Justi and van Driel 2005; Pilitsis and Duncan 2012; Windschitl and Thompson 2006). Science professors and science methods instructors must critically analyze their own teaching methodologies to appropriately model instruction and provide sufficient mastery experiences so that future teachers can enter their classrooms better prepared to meet these high expectations.

To establish understanding of the enhanced expectations in the NGSS, let us examine an example of the changes in the expected student learning outcomes in the authors' state standards for kindergarten in science. Currently, just one learning objective exists regarding forces for kindergarteners. It states that students should be able to "explore and state different ways objects can be moved (e.g., straight, circular, fast, or slow)." The NGSS are scheduled to be adopted in the state of West

Virginia in 2016, and they have two performance expectations regarding forces in kindergarten: “Students who demonstrate understanding can 1) plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object; 2) analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.” The NGSS requires students to “plan and conduct an investigation” along with “analyze data,” yet PSTs themselves may have never had a chance to practice these valuable scientific skills in their preparation courses. The opportunity to engage and support this type of instruction within a methods course in an after-school learning space provides PSTs a valuable learning experience.

Considering the rigor and challenges associated with teaching science, many barriers in teaching science, particularly during student teaching, have been examined by researchers which include the following: differing teaching styles and lack of support between mentor teachers and PSTs (Plourde 2002), time constraints (Plourde 2002), lack of confidence, little or negative prior experience with science and science teaching (Kelly 2000), and teachers’ beliefs about what science is (Brickhouse 1990; Pilitsis and Duncan 2012). In fact, *teacher* beliefs about their skills in science as learners and as facilitators of learning can significantly impact their effectiveness in the classroom. PSTs’ limited understanding of science and anxiety over their prior experiences in science limit their self-efficacy in teaching science (Bleicher 2007).

Self-efficacy is a person’s belief about his/her ability to produce a desired outcome (Bandura 1986). These beliefs come from their prior life experiences and frame their individual expectations with regards to new experiences (Bandura 1977, 1981). Undoubtedly, PSTs’ prior experiences as learners of science will impact their expectations of being successful as teachers of science. In fact, Olgan (2015) found that Turkish early childhood teachers struggle with confidence in teaching science because they believe they do not receive adequate teacher training.

Additionally, PSTs’ poor feelings about science may manifest themselves in feelings of high anxiety and dread. Watters and Ginns (2000) found that early childhood teachers typically have poor attitudes and beliefs about science and their ability to be effective teachers of science. Howitt and Venville (2009) expressed that many preservice early childhood teachers view themselves as “non-science” people. Teachers with more anxiety regarding science teaching relied upon teacher-focused instruction (Czerniak and Haney 1998; Czerniak and Schriver 1994). On the other hand, teachers who are more comfortable with science were more likely to devote more time toward teaching science and were more likely to teach science in more innovative ways (Westerback and Long 1990).

These two affective constructs of self-efficacy and anxiety provide the framework for consideration of service learning and elementary instruction. After-school instruction provides PSTs time to practice teaching science in an innovative and supportive way to overcome these barriers. This instruction also benefits local youth who may not be experiencing inquiry-based science in their formal classrooms. Not only do PSTs report more positive feelings about science and science teaching during their student teaching semester, they also incorporate creative formative assessment strategies. Unfortunately, they continue to struggle with relinquishing "control" of the classroom and finding sufficient time for student inquiry-focused investigations (Cartwright 2012). When given the time and support to teach science in this after-school service-learning setting, PSTs reported added motivation to confront barriers that are often associated with teaching science, which include a lack of confidence in science and science teaching and classroom constraints such as time and resources (Cartwright et al. 2014).

## Theoretical Framework

The theoretical framework for this study is situated within Bandura's work on self-efficacy and further supported by literature on barriers to science teaching and the benefits of the outside-of-school time environment. Self-efficacy and outcome expectancy beliefs are related to teaching performance (Bleicher 2007), while perceived self-efficacy greatly affects the level of motivation and accomplishments (Bandura 2000). Bandura (1977) explained that people avoid situations they think are beyond their ability, but they will perform those activities they think they are capable of doing. PSTs feel less confident in teaching science to their students when they experience science as boring or difficult in their own schooling experiences. Early education teachers' confidence in teaching science determines how frequently they teach science and which concepts they teach (Olgan 2015).

Elementary and early childhood PSTs have limited experience leading inquiry-based science instruction. Because teacher preparation programs cannot dedicate enough time preparing and modeling non-traditional science instruction, meeting the demands of reformed instruction can be challenging (Luehmann 2007). As a result, many teachers have difficulty setting up inquiry-based classrooms (Chiapetta and Adams 2000; Marx et al. 1994; Minstrell and van Zee 2000). This lack of experience teaching science contributes to another challenge early childhood and elementary PSTs face—a lack of confidence in teaching science. Teachers who feel confident in their teaching ability have been more likely to use inquiry and student-centered teaching strategies, while teachers with less confidence have been more likely to teach through traditional teacher-directed strategies like lectures and reading from a book (Czerniak 1990). Many elementary and early childhood PSTs feel unprepared to teach science (Kelly 2000) and, since they lack confidence, they tend to teach how they were taught (traditional teacher-directed instruction) or avoid science instruction at all.

PSTs can potentially alter their science-related identity and improve their confidence when given opportunities to engage in the informal teaching environment. Luehmann (2007) described how practice teaching in "nontraditional settings offers beginning science teachers unique 'safe' opportunities (low in accountability, high in support) to display competence, receive feedback, exercise agency, and assume a central role in inquiry-based teaching" (p. 835). PSTs have been given a sense of autonomy in the after-school environment not found in the traditional classroom's more restrictive environment (Cox-Petersen et al. 2005). Likewise, after participating in after-school learning, PSTs' outcome expectancies improved toward equitable science teaching and learning (Cone 2009). Similarly, during student teaching, PSTs who had taught science in an after-school program created safe learning environments and frequently incorporated students ideas through formative assessment (Cartwright 2012). As previously mentioned, PSTs also developed motivation to overcome barriers to teaching science (Cartwright et al. 2014).

Children are naturally curious about their environment and naturally begin to develop an understanding of the world where they live. Quality science experiences are needed by young children to help them develop scientific thinking skills that can then be transferred to critical thinking skills in other academic domains (Trundle 2010). French (2004) found positive correlations between preschool children's participation in a science program and their receptive language growth. Also looking at language growth, Henrichs and Leseman (2014) examined how early science instruction and academic language development fit together. They found that "simply making science-related materials available will not suffice to facilitate high-quality conversations" (p. 2992). While helping teachers feel more positive about science helps, as well as emphasizing how important early science experiences are, Henrichs and Leseman (2014) also claim that it is important to integrate language instructions in those experiences.

## Implications for Practice

Building upon the work of other research into the integration of service learning and methods courses (Cone 2009, 2012), the university set to infuse community-based service learning in the pre-school and elementary science methods course in one of the sections of the course. PSTs were placed in teams of two at different sites in the surrounding communities. Before beginning the methods course, suitable after-school partners were identified which provided an adequate learning space with desks or tables with minimal distractions from non-participating students and a classroom teacher who served as a mentor teacher to provide support for the PSTs. Most often the mentor teachers provided support for classroom management particularly. The learning space proved to be critical for success because inexperienced teachers struggled to obtain and sustain student attention if there were too many distractions by non-participating students. Most often, the best sites were schools that had after-school care programs in place with on-going enrichment activities that accustomed students to extended learning activities beyond the school day. The number and diversity of sites used each semester depended upon the number of PSTs enrolled in the methods course. Because of the diversity of these site locations, the PSTs' experiences were varied in terms of the number of students in attendance, the space and type of room, the age/grade level of students, and the behavioral expectations in place at each site. However, all sites had a suitable learning space with at least six students, one mentor teacher, and two PSTs to lead the science instruction.

After an initial period of preparation on the college campus for the after-school field experience, PSTs began implementing guided-inquiry science lessons provided by the program. Initially, these lessons were peer-taught within the methods course and then implemented at their after-school site the following week. This allowed the PSTs to view and practice each lesson before teaching it, while also learning about the science concepts 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 the final weeks of the course, PSTs implemented the science unit they developed with their co-teacher at their after-school site. The conclusion of the semester focused on reflections and analysis of embedded student assessment data.

The PSTs who participated in both of these alternative field experiences were followed through their student teaching semester. Our research team then observed them teaching a science lesson during student teaching and also interviewed them regarding their feelings about science, science teaching, and the impact that the after-school field experience had on their teaching.

The following sections outline the primary themes that were previously published in our examination of a group of PSTs as they transitioned from student to teacher during student teaching. PSTs expanded their ideas of science inquiry instruction to include multiple modes of formative assessment, but they struggled with the desire to keep "control" of the classroom and to not give students the correct answer (Cartwright 2012). Each of these themes will be discussed below, including our PSTs' experiences, along with a review of the literature to describe the implications for practice in the field of early childhood education.

## Science Talks: Thinking It Through Together

Instructional time and space were made available during the after-school field experiences for PSTs to lead student-centered discussions where students were asked to provide their ideas about the science concepts taught in the lesson. Too often, little time is devoted to develop students' ideas through social discourse in the formal classroom. Research has shown that only a small fraction of instructional time is spent on student discussion (Newton et al. 1999). The flexibility and time (at least an hour) provided in the after-school learning space facilitated sufficient social discourse and development of ideas because PSTs felt comfortable and did not have the pressure of knowing all the right answers or being "wrong."

After spending devoted time in the after-school setting during the science methods course, students were also observed during student teaching encouraging the collaborative development of ideas. Stephanie, a student teacher at a school in a low-income area, taught first-grade students about stars. An excerpt from an observation follows:

*Stephanie asks the children, "What is a star?" One child says a planet.*

*One child says that stars are little and then get big. One child says they are "out at night."*

*Someone says "the sun is the biggest star."*

*Stephanie replies, "I don't know. There are some pretty big stars."*

*A child says something about constellations, and Stephanie says that we can see constellations outside. She tells them to look tonight when it's dark to see if they can see any.*

*A girl says, "Stars can bloom." Stephanie asks what she means. "Like flowers do," is the child's explanation.*

*Stephanie reads them a book called "Stars." She asks them, "Why can't we gather stars in baskets?"*

*"They are too big," one child replies.*

*Stephanie says, "What if they are too far away?"*

*Another child says, "The wind blows them out."*

As the observation of Stephanie shows, giving children the time to think through their own ideas allows them to deepen their levels of thinking. They can build off of one another's ideas, such as when the child stated that the stars are behind the sun and another followed up saying that we can see the stars since we can see the sun. Another child demonstrated her ideas about stars using the metaphor of a flower blooming and how "stars bloom." She is able to form her own connections about stars based on an experience closer to her, flowers. As Lev Vygotsky noted in 1987, children need experiences at the everyday level and the scientific level in order to develop real scientific concepts. With the blooming flower connection, this child experienced science at the scientific and everyday level. Perry and Rinkin (1992) explained that early childhood teachers are not expected to fully explain scientific concepts and principles but, instead, prepare the right social and physical environment needed for children to engage in more demanding content and experiences. This social environment happens within a safe learning environment where sufficient time is devoted to discourse.

## Revealing Student Thinking: Formative Assessment

Since social discourse and student development of ideas were hallmarks of the after-school programs, PSTs relied on these formative measures to gauge student understanding. Without formal assessment measures such as a test or exam, PSTs were challenged to enact other embedded formative assessment measures that included questioning/discussion and creative writing strategies that often included concept mapping (Cartwright 2012).

Many of our PSTs included a significant amount of time devoted to both questioning/discussion (as discussed previously) and other creative written forms of formative assessment. One of our PSTs learned how to use pre- and post-instruction concept maps to measure changes in student understanding during her after-school field experience. She then continued using this strategy in her later clinical placements including student teaching. During her student teaching interview, she stated, "I actually took our concept map at the end and I actually kind of stole it and tweaked it for my reading block assessment for pre- and post-unit. My students gained so much from my unit, and I was just so excited." She described how she utilized different colors of post-its to record student thinking on different days. She likes using post-it notes with students for them to post their ideas. She said:

> *Kids love post-it notes. Because I know every time we handed out post-it notes, they were like, 'Oh my gosh! Yes, I've gotta have one!' So I wanted to use the post-it notes and then like on the Learn part* [*of the KWL chart*], *I do it in different colors for each day* [*so*] *I know like what I still need to cover and what we've already learned.*

Student achievement may be enhanced through this type of formative assessment, especially when there is an openness in the room and students feel comfortable and "safe" to share their ideas and understandings (Black et al. 2003).

## Giving Up Control and "THE" Correct Answer

As demonstrated in the introductory scenario, students often have very interesting ideas about how the world works. Educators must decide whether or not they will support a safe classroom environment where students feel confident to offer their ideas and risk being wrong. Too often, teachers are unwilling to give up "control" of the instructional space and step in too quickly to provide "THE" correct answer which often curbs students' willingness to take risks and share their ideas (Cartwright 2012). While in her kindergarten student teaching placement, Lisa described her shock when she realized that the students were already afraid of being wrong and taking risks. Lisa had to work hard to encourage them to share their ideas and not immediately receive feedback on whether those ideas were right or wrong. Lisa acknowledged, "You can see the benefits of shutting up and letting them go." In fact, Lisa described the benefits of making time to listen to their ideas and not telling them THE correct answer in the following excerpt from her student teaching interview:

> *It forces them to be critical and independent thinkers. And we have in our society* [. . . ] *that we want to think critically and independently, but we don't reinforce it* [. . . ]. *You ask them a question; they get the wrong answer. You tell them what the right answer is. You don't give them the opportunity to reflect and say, "Well, would it work that way? Why would it work that way?" Let them come up with it on their own. It's going to be a lot more beneficial, and they're going to take that with them* [. . . ].*They came up with it by themselves. It gives them ownership on that answer, on their conclusion that they've come to, and they'll learn. They'll find that it's another way if they're wrong. A lot of times they're not.*

When teachers step in too quickly with THE "one" right answer, the opportunities for students to struggle and co-construct meaning are lost. Siry et al. (2011) state:

> Learning science is a collective achievement, as individual participants ‘do’ science in interaction with others. In these interactions, participants share and co-construct meaning within the situation at hand as they draw on a variety of resources (in the form of experiences, prior knowledge, cultural practices, etc.). These resources are permeated with specific meaning by past use and have a shaping function on the activity in progress, while at the same time new meanings might emerge and get reshaped over time. (p. 313)

By giving up control and allowing students to think through their ideas, children are able to create their own new meanings about scientific concepts. Siry et al. (2011) also state that science comes into existence “as it is done within interaction” (p. 313) in which interactions continue to be shaped by the activity and the context through multiple interactions. As science is done, it is “talked into being” (p. 313). When early childhood educators examine students’ discussions, they often notice young children’s complex and sophisticated understandings of science (Pekarek-Doehler and Ziegler 2007). PSTs were able to make improvements in these challenging areas of instruction with support offered through the after-school field experience.

## Summary

The rigor of the NGSS implementation in the primary grades has been put in place to better prepare early childhood and elementary students, but the challenges of these performance expectations are daunting for early education teachers. Early education teachers feel high anxiety regarding science and science instruction and have limited chances to actually experience inquiry-based instruction in science at the collegiate level. Not only do PSTs often find few examples of what engaging science instruction is (Crawford and Cullin 2004; Justi and Gilbert 2002; Justi and van Driel 2005; Pilitsis and Duncan 2012; Windschitl and Thompson 2006), their attitudes about science may hinder their self-efficacy and actual ability to teach hands-on, inquiry-based science. All too often, PSTs’ poor attitudes about science and low self-efficacy regarding science teaching negatively impact science instruction in the early education classroom (Watters and Ginns 2000). Service learning provides PSTs instructional practice to overcome barriers related to science teaching (Cartwright et al. 2014). Examining these PSTs’ practices during student teaching reveals that they include creative formative assessment strategies, yet they still struggle to relinquish “control” of the classroom. In addition, they overcome common barriers associated with science instruction including low self-efficacy, lack of content knowledge, and classroom constraints such as time and materials (Cartwright et al. 2014).

Although the merit of more time teaching is clear, critical components of this program should be considered before replicating a version of this program at another location. Providing the PSTs sufficient materials, innovative guided-inquiry lessons, and a distraction-free learning space were all found to be critical. PSTs also appreciated having a mentor teacher who was on hand to solve classroom management issues when they occurred. A limitation to implementing this program would be securing sufficient materials for the science lessons and finding sites with an available classroom teacher to serve as mentor.

Because the demands and rigor necessary for successful implementation of NGSS are challenging, traditional preparation programs for early childhood and elementary educators need reevaluated and reformulated to ensure that our graduates are prepared to meet the demands. Field experiences are undoubtedly the most common strategy for providing PSTs mastery experiences in leading instruction. Providing non-traditional instructional field experience opportunities builds upon previous research on after-school science teaching, which has revealed that opportunities for supported, inquiry science education allow PSTs to put into practice theoretical concepts to benefit students in the classroom. In addition, these experiences have another central outcome that relates to the potential for institutional transformation and adoption of an elementary science practicum utilizing the after-school environment within baccalaureate elementary education programs. To substantiate the long-term impact of this experience, one of the authors is conducting intensive follow-up research with past graduates who are now teaching in their own classrooms to determine how and in what ways this experience impacted their instruction. As the impact of the after-school teaching experience on PSTs is further evaluated, researchers hope to provide support for more widespread implementation of a non-traditional elementary science methods course that incorporates after-school instruction.

**Acknowledgement** This work was supported by the National Science Foundation [grant number 1031456].

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