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Beginning Elementary Mathematics Teachers Negotiating Leadership Responsibilities

Catherine Stein Schwartz & Anne Swenson Ticknor

Abstract: *Induction has been given much attention in recent years. Research indicates that a comprehensive program with multiple supports for new teachers, including reasonable teaching loads and complete curriculum resources, is most effective. However, this is not the reality for many beginning teachers. In a study of a two-year, university based, mathematics-specific induction program for elementary teachers, we found many first year teachers were given teacher leadership responsibilities at their schools. These leadership experiences were confounded by school contexts in which curriculum resources were incomplete or competed with their visions of "good" mathematics teaching. Qualitative data included interviews, surveys, written reflections, and researcher field notes from the first year of study. This article reports three first-year teachers' experiences of significant leadership responsibilities. Findings call for ways to prepare BTs in undergraduate and induction programs for non-instructional duties in teaching, and ways to develop the agency needed to negotiate school-based contextual constraints.*

Induction has been given much attention in recent years, particularly as districts and states try to decrease teacher attrition. Largely the purview of local districts, many induction programs focus on classroom management and familiarizing beginning teachers (BTs) with district policies rather than content-specific support to help them enact curriculum (Luft, et.al., 2011). Research indicates comprehensive programs with multiple supports for new teachers including reasonable teaching loads and complete curriculum resources are most effective (Alliance for Excellent Education, 2004; Smith & Ingersoll, 2004).

Birkeland and Feiman-Nemser (2012) note that even a comprehensive set of new teacher supports are not enough if new teachers are being enculturated into schools that do not have a shared vision of a strong professional community including a commitment to reasonable teaching loads. In a study of a two-year, university-based, mathematics-specific induction program for elementary teachers, we found many participants were given teacher leadership responsibilities at their school as first year teachers. These leadership experiences were confounded by school contexts in which curriculum resources were incomplete or competed with the BTs' visions of "good" mathematics teaching.

We use Hammerness' (2006) definition of vision as "ideal images of classroom practice." Our program goals were to:

1) Help BTs navigate the particulars of classroom teaching as they attempted to enact their vision — particular students at a particular grade in a particular classroom at a particular school;

2) Support BTs in refining their visions in line with reform-based mathematics teaching practices (Munter, 2014); and

3) Develop BT's pedagogical agency (Ticknor & Schwartz, in press).

The culture of schools greatly influences whether BTs take up reform practices or return to the status quo (McGinnis, et.al., 2004). Through a program external to the school context, we provided places for open discussion and development of shared vision of mathematics teaching. BTs participated in three days of professional development (PD) in a residential setting the summers before and after their first year of teaching with two follow-up PD days during the year. Mentors and professional developers with subject-matter expertise worked with BTs to understand and negotiate district-provided curriculum resources and to grow in their mathematics teaching practice. Specifically, mentor elementary teachers who had a graduate elementary mathematics certificate had phone conversations with BTs every three weeks to discuss mathematics instruction. In addition, all BTs and the mentor at each grade level planned and taught shared lessons and analyzed student work together at PD sessions.

We accomplished the initial goals of the program by supporting BTs' visions of ideal practice and mathematics pedagogy. However, we found that while these were essential building blocks of a successful first year of mathematics teaching, another set of particulars often dominated our work. These were the particulars of the larger school context (Schwartz & Ticknor, under review). One challenge faced by several participants in the group was an expectation of teacher leadership despite the recommendations for exemplary induction practice that new teachers be given reasonable if not reduced teaching assignments (Birkeland & Feiman-Nemser, 2012). We will share the stories of three BTs simultaneously negotiating their first year of teaching and significant leadership responsibilities. Each teacher's experience offers different insights into the reasons and ways BTs assumed leadership roles in school settings.

METHODS

The data for this article derives from the first year of a two-year study of a mathematics-specific induction program — Project Launch — in the eastern region of a southern state in the United States. Twenty elementary BTs and six mentor teachers participated in this study (for more information about Project Launch see Ticknor & Schwartz, under review). In this article, we include data from three BT participants, Alisha, Janine, and Lindsay, to provide a closer look at the theme of teacher leadership. Our analysis centered on end-of-first-year BT interviews, end-of-first-year BT surveys, BT written reflections, and researcher field notes from Year 1 (for more information see Ticknor & Schwartz, in press).

Our qualitative analysis was multi-layered and recursive. First, we read each data source for emerging themes. Next, we conducted a content analysis to determine key ideas and themes emerging from commonalities across data. After we reached a consensus about themes in data, we developed working definitions of each theme and identified categories that corresponded with themes. As more data was collected, we continually reviewed initial analysis and adjusted categories when new responses did not fit using constant comparison methods (Glaser & Strauss, 1975). Finally, we read across entire data for patterns to strengthen the external validity (Merriam, 1998) of the findings. A mutual consensus was required for final categories. Examples from the data from each BT for the category of teacher leadership is presented in the next section.

FINDINGS

Analysis of Year 1 data indicated BTs engaged in teacher leadership responsibilities during their first year as teachers in their grade levels and schools. Each BT experienced teacher leadership differently. Alisha became a leader by default; Janine became a leader due to perceived expertise; and Lindsay's leadership was hidden from colleagues. Illustrative quotes highlight the ways BTs assumed leadership roles in their particular school settings while simultaneously negotiating their first year of teaching.

Alisha began the first year of teaching with both veteran and beginning third grade teachers. However, by the middle of the first year, the more experienced teachers had left either the grade level or the school. The replacement teachers were all BTs just graduating from their program, leaving Alisha, with four months, as the most experienced third grade teacher in terms of the amount of time in the classroom. In the end-of-first year interview Alisha reflected, "It was terrifying because halfway through the year I was the one with the most experience." With the most experience also came the role of grade-level chair. Alisha shared, "As a new teacher I shouldn't have to do it, but I did it anyway." What Alisha "did" was the grade-level assessment coordination and planning mathematics instruction for the grade-level team. When asked about her role as a teacher leader Alisha replied, "I never felt like a leader, but I do now." This statement indicates

Alisha's increased sense of power, which may have contributed to her agency as a BT. When asked about her plans for the upcoming year, Alisha continued, "I am excited about others being leaders for other things (grade-level field trips, incentives, etc.) ... I hope this year I will be more prepared to lead our grade level in math teaching." Alisha's statements reflect both the hope for other grade-level teachers to share in leading the grade-level and her plans to continue as a teacher leader.

Janine's leadership role was also tied to grade-level team lesson planning and mathematics content knowledge. Janine's undergraduate mathematics concentration and her participation in our mathematics-specific induction program positioned her as the grade-level mathematics "expert." With knowledge came responsibility to write shared mathematics lesson plans for her second grade teacher team members, each with more teaching experience than she. In the beginning of the school year, Janine co-planned mathematics instruction for the grade level with a colleague, as the year progressed, so did Janine's leadership role. Eventually Janine solely wrote the mathematics lesson plans for the grade-level team, using her school's menu style lesson plan format, which is structured like a multi-course meal in a specific order. Janine did not find the format conducive to student inquiry because it "doesn't allow for a lot of flexibility." Janine continued, "I planned [math for the team] using it because we have to use it." However, Janine did not use the menu lesson plan in her own teaching. Instead, Janine wrote two sets of lesson plans: one for colleagues and one for herself, which was more reflective of the vision she was trying to enact in her pedagogy. Writing two sets of lesson plans for mathematics increased Janine's thinking about pedagogy, which may have contributed to her agency as a BT.

Lindsay became a teacher leader in the school through close administrator contact. Lindsay's principal regularly checked-in about professional development activities including Project Launch, which Lindsay attended during the first year of teaching. Lindsay's grade-level colleagues were not as welcoming of her new ideas, advising her not to bring anything into her classroom unless everyone else was using it. Instead, Lindsay would share her resources and ideas with the principal. Lindsay shared, "My principal is open to new ideas and I talk with her about Launch." Lindsay's principal would often inquire about "new ideas" Lindsay learned in professional development settings and then share Lindsay's ideas with school faculty. Lindsay said, "I told her about mClass Math because I heard about it at a conference and then we had a webinar at a faculty work day." Lindsay was pleased to know "she does listen" to the ideas, Lindsay shared. However, Lindsay's principal did not share where the ideas were learned. Lindsay stated, "Then I told her about Planbook (an online organizational tool) and then she told people they should buy it. She didn't tell them it was because of me." Even though Lindsay did not seek credit for sharing the idea, when school colleagues had questions about how to use the tool, they were directed to Lindsay since she had been using it. By answering their questions, she was positioned as an expert. Lindsay shared, "Then everyone came to ask me about it. A little part of me is like, 'yay.' So maybe (the principal is) excited about my ideas." Through the administrator, Lindsay not only had the agency to enact her vision in spite of discouragement from grade-level teachers, she was able to affect change on a school-wide level.

DISCUSSION

Despite calls for reasonable teaching assignments (Birkeland & Feiman-Nemser, 2012), some first year elementary teacher participants in our university-based, mathematics-specific induction program assumed leadership roles beyond their own classrooms. We highlighted the stories of three BTs' as examples of typical experiences in which participants took on additional responsibilities for different reasons and in different contexts. Alisha served as grade-level chair by default because experienced teachers at her grade level left mid-year. Janine wrote mathematics lesson plans in the required format for her grade level because of her perceived expertise, even though she felt the format was not in line with her vision of "good" mathematics teaching. She then wrote a second set of mathematics lesson plans to use in her own classroom. Lindsay chose to resist her grade level's advice to do what everyone else does in part because of her principal's interest in her ideas. Due to the social impacts of this resistance, Lindsay's leadership was at first hidden as the principal shared her resources with the faculty without her being named as the source. By the end of the year, she was beginning to get credit for her ideas more publically as people became aware of her role.

Much of the BTs' visions were different from school expectations. They all cited the support of Project Launch, and specifically the program mentors, in facilitating their agency to pursue the enactment of their vision in the classroom, while still within the constraints of their school contexts. Although the additional responsibilities were a struggle throughout the year, in the end, all three BTs reported having increased knowledge and an increased sense of confidence because of the experiences.

The increased knowledge and confidence that comes with responsibility (or in Lindsay's case, administrator buy-in), may have been a factor in the sense of agency they felt to "go against the grain." We do not suggest placing teacher leadership responsibilities on first year teachers simply to develop agency. However, more research is needed to explore BT agency when making mathematics instructional decisions, particularly in settings where their vision and the particulars of the school context do not align. Alisha, Janine, and Lindsey offer glimpses of challenges faced by BTs that are beyond the scope of traditional teacher education and induction. Finding ways to help undergraduates and BTs develop the agency needed to negotiate school-based contextual constraints, and prepare them for teaching responsibilities beyond the classroom is of paramount importance.

REFERENCES

Alliance for Excellent Education. (2004). *Tapping the potential: Retaining and developing high-quality new teachers.* Washington, D.C.: Alliance for Excellent Education. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=C10A88548FE8EDCEE565D14D60E6C7DB?doi=10.1.1.363.2572&rep=rep1&type=pdf

Ticknor, A.S. & Schwartz, C.S. (in press). 'It just got real:' Navigating the affordances and constraints of school-based learning in a mathematics-specific induction program. Action in Teacher Education

Schwartz, C.S. & Ticknor, A.S. (under review). The role of university-based induction in beginning elementary teacher enactment of effective mathematics teaching Birkeland, S. & Feiman-Nemser, S. (2012). Helping school leaders help new teachers: A tool for transforming school-based induction. *The New Educator*, 8 (2), 109-138.

Glaser, B., & Strauss, A. (1975). *The discovery of grounded theory: Strategies for qualitative research*. Chicago, IL: Aldine.

Hammerness, K. (2006). *Seeing through teachers' eyes: Professional ideals and classroom practice.* New York: Teachers College Press.

McGinnis, J.R., Parker, C., & Graeber, A.O. (2004). A cultural perspective of the induction of five reform-minded beginning mathematics and science teachers. *Journal of Research in Science Teaching*, 41(7), 720-747.

Merriam, S. B. (1998). *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass.

Munter, C. (2014). Developing visions of high-quality mathematics instruction. *Journal for Research in Mathematics Education, 45*(5), 585-636.

Smith, T.M. & Ingersoll, R.M. (2004). What are the effects of induction and mentoring on beginning teacher turnover? *American Educational Research Journal*, 41(3), 681-714.

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Re-envisioning the School Day:

Integrating Mathematics, Science, and Reading through Students' Engagement with Practices

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Abstract*: In this article, we propose an alternative to traditional content integration that has resulted in our preservice elementary teacher candidates designing lessons centered on developing focused practices throughout a re-envisioned school day. We first present connections among the practices outlined in mathematics, science, and reading standards; the complementary nature of the practices creates a conceptual thread that weaves through and helps unite content across disciplines. Then, we outline the project that our teacher candidates complete, with descriptions of resulting examples of their work. We conclude by presenting suggestions for educators and other leaders who are interested in utilizing this lesson planning approach in their own settings.*

Keywords: standards-based practices, elementary school, lesson planning, mathematics, science, reading

Classroom teachers are often encouraged to integrate content across disciplines (Fogarty & Pete, 2009), particularly at the elementary level. Curriculum integration can be a challenge, due, in part, to the demands of teaching in this era of high-stakes testing and accountability (Brand & Triplett, 2012). We propose an alternative to traditional content integration that has resulted in our teacher candidates designing lessons centered on developing focused practices (e.g., argumentation, asking questions, and using models) across the school day. In most recent standards documents such as the *Common Core State Standards* (CCSS; NGA & CCSSO, 2010) and the *Next Generation Science Standards* (NGSS; Lead States, 2013), practices are emphasized with the expectation that students are engaging with high-level practices as they learn content.

We are teacher educators at the same university working collaboratively to prepare our candidates to become elementary-school teachers, but we each focus on different disciplines (mathematics, science, and reading education). Our teacher candidates take discipline-specific methods courses focused on the upper elementary grades (3-5) in the same semester. The ideas presented in this article result from the implementation of a cross-course, lesson-planning project. This article has three aims:

1) to describe the project and its goals;
2) to provide resulting examples; and
3) to present suggestions for educators and other leaders who would like to implement this approach to lesson planning.

While our work is situated in the elementary grades, we believe the approach presented herein can translate to middle and high school contexts with some modifications, as detailed in the article's conclusion.

THE PROJECT

The purpose of the multi-course project is twofold. First, it is designed to help teacher candidates think more deeply about new ways to organize a full day of instruction around common practices found in national standards. Second, an important byproduct of this project is that the students in the classrooms of our teacher candidates develop an appreciation for how the curricula of various subjects connect to and build on each other. The type of curricular integration we are describing moves beyond a thematic unit focused on a single topic. For example, a unit on "bears" may include students researching facts about bears in science, solving story problems about bears in math, and reading a book about bears. These tasks may lead to students making only superficial content connections and learning surface-level content.

Our integration model is not driven by content demands, but is instead driven by the development of standards-based practices (NGA & CCSSO, 2010: Lead States, 2013). The complementary practices become the conceptual thread that weaves through and helps unite the content. If selected and leveraged thoughtfully, the targeted set of related practices lend much-needed coherence to the work that students do in a given school day.

When one examines the individual sets of practice standards for mathematics, science, and reading, the connections become apparent, and the common educational aim of preparing citizens for critical thinking, problem solving, and communication skills required for careers becomes self-evident (Stage, Asturias, Cheuk, Daro, & Hampton, 2013). *The Standards for Mathematical Practice* (SMPs) in the CCSS for Mathematics (CCSS-M) (URL: http://www.corestandards.org/Math/Practice/) build on previous standards (NCTM, 2000) and years of research about the ways children learn mathematics. For example, we know the ability to "construct viable arguments" is important to make sense of mathematical concepts and deepen understanding and, in fact, is a practice in which mathematicians engage. Similarly, scientists "engage in arguments with evidence" when they share findings and claims from investigations, hence the reason the *Scientific and Engineering Practices* in the NGSS (URL: http://www.nap.edu/read/13165/chapter/7) outline that K-12 students should engage in this practice while learning science content. NGSS portrays a vision of "three-dimensional learning" to include content knowledge, crosscutting concepts, and science and engineering practices. 3-D learning engages students with the practices in the context of a core idea and crosscutting concepts (e.g., patterns, cause and effect). Like the CCSS-M and the NGSS, the *Reading Anchor Standards of the CCSS for English Language Arts* (URL: http://www.corestandards.org/ELA-Literacy/CCRA/R/) suggest practices in the form of general expectations for what students should be able to do as readers across grade levels. The anchor standards "define general, cross-disciplinary expectations for College and Career Readiness" (Cunningham & Cunningham, 2015, p. 2). The types of learning experiences advocated by each set of standards are exciting, but to become a reality for students, lesson planning needs to be fueled by both the content and practices.

For the assigned project, teacher candidates chose one practice from each set of standards to develop throughout a school day. Chosen practices had to be complementary or synergistic; in other words, there had to be an overarching thread that tied the practices together. Table 1 displays three examples of practice connections that our teacher candidates used. Candidates developed lessons for mathematics, science, and reading to meet focal content standards, based on the pacing guides provided by the school system in which our candidates are teaching. The candidates' lesson plans had to address how the selected tasks promoted their elementary students' use of the chosen practices. Furthermore, candidates were required to make the goal of developing the practices explicit to their students throughout the school day.

Table 1
Example Connections[1] *among Practices in National Standards*

Standards for Mathematical Practice (CCSS-M)	Practices in the Next Generation Science Standards (NGSS)	Reading and Language Arts (CCSS-ELA)		Connecting Thread
Make sense of problems and persevere in solving them	Asking questions (for science) and defining problems (for engineering)	Analyze how and why individuals, events, or ideas develop and interact over the course of a text		Problem Solving
Model with mathematics	Developing and using models	Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole		Modeling
Construct viable arguments and critique the reasoning of others	Engaging in argument from evidence	Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of evidence		Argumentation

[1]This table is not exhaustive in terms of connections among practices.

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EXAMPLES

We now turn our attention to two of our teacher candidates by describing their lessons and how they integrated their instruction through practices, rather than content.

Ms. Hamilton. Ms. Hamilton (pseudonym) re-envisioned the school day by anchoring her fifth-grade lessons around the practice of "modeling." As Ms. Hamilton said, "people use modeling every day to help them visualize or consolidate information." Ms. Hamilton began her school day with a reading lesson focused on analyzing the structure of text (e.g., the author's use of headings, subheadings, and paragraph structure) and using models for comprehension. Students read an article about the "Great Pacific Garbage Patch (GPGP)," a vortex in the northern part of the Pacific Ocean with high concentrations of chemical sludge and other debris. Ms. Hamilton's students used the structure of the text to create their own graphic organizer that became a model to show the relationships among humans, the GPGP, and sea organisms.

After the reading lesson, Ms. Hamilton taught her science lesson, where she also utilized the use of models. Her students sorted pictures of sea organisms into three categories: producers, consumers, or decomposers. Then, they completed the same sorting activity, but the pictures included descriptions and names for each organism. The additional information allowed students to correct their misconceptions. Ms. Hamilton and her class then discussed if the current models (from sorting) showed the relationships *between and among* the organisms. When they agreed that no relationships were shown, students created food chains and subsequently engaged in a discussion about how their new models helped them understand relationships and deepen their knowledge of sea organisms.

Later in the school day, Ms. Hamilton's mathematics lesson involved students modeling a real-world mathematical situation. A packaging company needs to make a box (rectangular prism) with a volume of 24 cubic inches for holding a serving of popcorn. The students built the various box options using multi-link cubes and documented each box's dimensions. Then, they recommended and justified a popcorn box option to the packaging company. Students utilized modeling while building their conceptual understanding of volume.

Ms. Norton. Ms. Norton (pseudonym) focused her re-envisioned school day in fourth grade on argumentation; in her words, the focus "allowed the students to develop an in-depth understanding of the topics at hand." Her day began with a mathematics lesson focused on decimals and place value. Before any formal instruction, students worked in pairs to respond to a mathematical statement (e.g., 0.1 is equal to 1/100). They wrote arguments as to whether the statement was true or false and provided supporting evidence, and then exchanged papers with another pair to provide critique of each other's argument. After a lesson on decimals and place value, the students examined their original arguments and peers' critique, and revised as necessary.

In reading, students worked in trios to develop an argument about the pros and cons of recycling after reading an article on the topic. They used evidence from the text to support their arguments and engaged in a whole-class debate. After the debate, students worked individually to write an argument with supporting details either in support or against recycling.

In science, Ms. Norton taught a lesson on the basic differences among sedimentary, igneous, and metamorphic rocks. Then, working in small groups, students examined a rock provided by Ms. Norton. They developed an argument for how they classified the rocks by citing specific evidence, and then created a short video of their arguments. Students watched each other's videos and critiqued the arguments.

OUTCOMES

Ms. Hamilton, Ms. Norton, and most of our other teacher candidates reported on the power of integrating through practices across the typically separate disciplines, both in their students' experiences and in their own pedagogy. One teacher candidate commented that her re-envisioned day gave students new "insight on strategies they can use to learn across multiple content areas, as opposed to viewing learning as having different approaches to each new concept." Ms. Hamilton commented on her own instructional practice, stating she found herself paying "more attention to observing students' progress to check that they were developing the practices."

SUGGESTIONS

The outcomes of our teacher candidates' projects indicate this approach to lesson planning has the potential to heighten students' and teachers' appreciation for the many ways the various "subjects" connect to and complement each other. After implementing this project with two cohorts of teacher candidates, we offer three suggestions for other educators interested in using this lesson planning approach.

Ensure a clear thread exists to tie the practices across the disciplines together. There are numerous connections across the practices in the national standards that can be made. However, the key is to ensure the thread or glue that connects practices from different disciplines together is apparent. In the case of our teacher candidates, we had a few candidates whose targeted practices were only superficially related. The stronger units of instruction synthesized the full text descriptions of the targeted standards before building a day of instruction focused on the development of practices within and across disciplines.

Keep the content objective central to the lesson, making sure it does not get lost. While it is exciting to get students engaged in targeted practices, it is important that the content to be developed does not get lost. This loss of content happened for some of our teacher candidates in that the lessons they planned emphasized students' development of the selected practices at the expense of the content learning objectives. As teachers identify both practices and content objectives during planning, teachers need to verify that the practice is developed through the content. The learning objectives should remain the driving force behind the features of any activity, while the practice becomes explicit in the ways that students engage with the content. Simply put, it is important to ensure that the content covered will allow you to "feed" the development of the chosen practice.

Be explicit with students about the practice(s) they are developing. We alluded to this point earlier, but we want to emphasize its importance. It is essential to make the connections explicit to the students throughout their work by using sentence frames such as the following: "Remember when you were using evidence in your arguments about _____ in science. We can make similar evidence-based arguments in math/reading when we ______," or "Just as we used a model of _____ to represent _____ in science, we can use models in math to reason about _______."

CONCLUSION

Although our teacher candidates work in elementary settings where teachers typically teach multiple subjects, we argue this approach to lesson planning could also be implemented in middle or high schools. In middle schools that utilize teaming, common practices can become part of planning discussions, and teams could focus on common practices as students move among classrooms throughout the day. In cases where there are not teams, as is true in many high schools, a solution may be that multiple departments focus on the development of a common practice for a unit of instruction. For example, the mathematics and science departments could choose to focus on argumentation for a duration of time in all of the courses they teach. In so doing, students would experience practice-based connections across the disciplines. Another approach could be a school-wide focus on common practice(s) for an extended period of time (e.g., an academic quarter). This approach could be beneficial for schools who utilize semester-long courses where students do not necessarily enroll in both a mathematics and science course, for example, in the same semester.

With the clear attention to developing practices found in the standards, this powerful approach to lesson planning is a natural and appropriate way to integrate instruction. This form of planning has the potential to unveil for students how their work as mathematicians, scientists, and readers are actually quite similar. One of our teacher candidates captured the power of this lesson planning approach well when she said:

> *Highlighting a common practice across multiple content areas unifies instruction and enables students to better transfer their knowledge. It shows students that education is not compartmentalized; that is, the methods of thinking that they learn in one subject can and should be used in other disciplines, both in and out of the classroom.*

We believe this unification of instruction can bring coherence to the work of teachers' daily planning and can in turn create new feelings of excitement and efficiency.

REFERENCES

Brand, B. R., & Triplett, C. F. (2012). Interdisciplinary curriculum: an abandoned concept? *Teachers and Teaching: Theory and Practice*, *18*(3), 381-393. http://dx.doi.org/10.1080/13540602.2012.629847

Cunningham, P.M. & Cunningham, J.W. (2015). *Teaching Common Core English Language Arts Standards: 20 Lesson Frameworks for Elementary Grades.* Bloomington, IN: Solution Tree.

Fogarty, R. J., & Pete, B. M. (2009). *How to Integrate the Curricula*. Thousand Oaks, CA: Corwin Press.

Lead States. (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press. https://www.nap.edu/catalog/18290/next-generation-science-standards-for-states-by-states

National Council of Teachers of Mathematics (2000). *Principles and Standards for School Mathematics*. Reston, VA: Author.

National Governors Association Center for Best Practices & Council of Chief State School Officers (2010). *Common Core State Standards*. Washington, DC: Author. http://www.corestandards.org/

Stage, E. K., Asturias, H., Cheuk, T., Daro, P. A., & Hampton, S. B. (2013). Opportunities and challenges in next generation standards. *Science*, *340*(6130), 276-277. DOI:10.1126/science.1234011

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Talking Science: It's Not Elementary!

Improving Elementary Pre-service Teacher Discourse Skills through a Scaffolded "Science Talks" Assignment

Tammy Dutton Lee, Bonnie Glass

Abstract: *Learning science requires communication between participants, however creating effective discourse for elementary classrooms has shown to be a difficult task. In this article, we highlight an assignment given to undergraduate elementary pre-service teachers concentrating in elementary science. Transcripts of elementary pre-service teachers' (EPST) "Science Talks" have been reviewed and, over the course of three semesters of implementation, scaffolds have been put in place to provide EPSTs with strategies and tools necessary to better plan, implement, and evaluate science discourse. Initial findings, which point to the effectiveness of this assignment and the additional scaffolding, will be discussed. These findings have potential applications for teacher education programs as well as for in-service teacher professional development.*

Keywords: Science Discourse; Talk Moves

Rationale for "Science Talks" Assignment

Science education researchers acknowledge the importance of socially constructed knowledge when learning science (Alexopoulou & Driver, 1996; Bianchini, 1997; Kelly & Crawford, 1997; Kelly & Green, 1998; Linn & Burbules, 1993; Richmond & Striley, 1996). Therefore, science teachers should engage students in knowledge-building processes using discourse as an essential component (Duschl, 2008). A majority of classroom discourse is structured in a way that does not provide opportunities for students to engage in the construction of ideas (Alexander, 2008; Lyle, 2008). Kovalaninen and Kumpulainen (2005) observed that teacher-initiated talks during science investigations in elementary classrooms were described as information-driven with teachers providing knowledge as opposed to fostering evidence-based discussions among all participants. This common method of class discussion results in students' contributions being brief responses that require no student reasoning or critical explanations.

At our southeastern university, we have a subset of elementary education majors who have chosen to concentrate in elementary science. This Elementary Science Concentration (ESC) involves taking specific science content and methods courses focusing on teaching K-6 science. Five of the courses (Life, Earth, Physical, Elementary Science Methods, and Informal Science) are taught within the science education program in the college of education. As professors of elementary science education courses, we recognize the challenge elementary pre-service teachers (EPSTs) face when planning and teaching effective science lessons. Through our experiences with pre-service teachers, both in our class discussions and in video-recorded lessons, we observed the complexity of orchestrating discourse skills and the need to support the development of such skills. As stated, research has provided widespread agreement that academically productive talk is critical for learning science (NRC Consensus Report Taking Science to School, 2007). To better prepare EPSTs for the challenge of creating "academically productive talk" we developed our "Science Talks" assignment that focused on planning and implementing effective discourse on a core idea in science.

CLASSROOM DISCOURSE

Students' abilities to construct explanations of scientific phenomena that incorporate current understandings of science are a major component of the *Next Generation of Science Standards* (Achieve, 2013). Classroom discussion addresses essential academic content, exposes alternative ideas, and clarifies understanding; therefore, it is a critical component of every lesson. Sandoval and Morrison (2003) argue that, in order to understand the actual practices of science, students need explicit discourse experiences, which require them to construct their own evidence-supported explanations. Language should be viewed as alive, not as a static phenomenon (van Eijck & Roth, 2011; Roth, 2008); therefore, it should be constantly moving between participants. During an active "talk," teachers and students explore ideas and use evidence to build and critique academic arguments. When a talk becomes static, classroom instruction tends to focus on vocabulary, which can deter the development of science language (Richardson-Bruna, K., Vann, R., & Escudero, M.P., 2007) and conceptual knowledge.

The construction of scientific knowledge is a social process through an engagement of negotiation and consensus building (Tobin & Tippins, 1993). The skill necessary for facilitating these types of discussions among students is recognized nationally as essential (Mercer, 2008) and complex. The difficulty lies with helping EPSTs learn how to conceptualize classroom discourse, which involves two important aspects — understanding the sequencing of the talk while managing the engagement of students (Lehesvouri, Viiri, & Rasku-Puttonen, 2011). One of the essential components of a successful talk is the extent to which students are treated as active agents in classroom discourse (Alexandra, 2006). Elementary pre-service teachers need help in planning and implementing effective classroom discourse. Therefore, they should have experience planning and implementing questions within a real talk. To make sure the talk is active, planned questions are evaluated and the interactions involving the questions are explored. Knowing how and when to ask questions and how to navigate student responses is essential and multifaceted (Molinari & Mameli, 2010).

"SCIENCE TALKS"

To address this need, we developed an assignment called, "Science Talks." Students in each of the ESC content courses prepare, facilitate and reflect on one "Science Talk." They also participate in three additional talks led by their peers each semester. Facilitators are provided with an assigned Page Keeley assessment probe (Keeley, P., Eberle, F., & Farrin, L., 2005). Probes include a scenario focused on elementary science content, related student misconceptions, and preconceptions. The associated "Teacher Notes" by Keeley are provided, which include background information and suggestions for implementation.

Prior to leading a talk, EPSTs complete a "Planning My Science Talk" assignment. This assignment, in initial implementation, required EPSTs to research science content related to the prompt, demonstrate understanding of the assigned prompt, and develop a potential "discussion map" of questions with which to engage students. EPSTs used instructor feedback on the "Planning My Science Talk" assignment to make required revisions and conducted a 10-minute video-recorded round table discussion with their peers. Facilitators viewed their videos and reflected on their individual talks.

"SCIENCE TALKS" INITIAL ATTEMPT

Thirty-four EPSTs in the Physical Science course were the first students to experience the "Science Talks" assignment. Transcripts were reviewed and some factors affording discussion were noted; however, factors constraining discussion predominated with recurring themes. For example, often EPSTs posed a question but rarely did they ask a follow-up question to make student thinking visible. In some cases, EPSTs ignored incorrect responses by their peers or responded affirmatively to responses that were inaccurate. In other cases, they provided feedback or explained content incorrectly (e.g. "air is a good conductor of heat," "the starburst is melting in your mouth," "the change from liquid to gas is dissolving"). In several cases, EPSTs introduced common misconceptions rather than engaging their peers with questions to "unearth" these misconceptions. Rarely did EPSTs demonstrate active listening in which they probed deeper and required students to explain their thinking.

EPSTs also struggled with novice teacher issues including not having thought through how they would introduce the talk to students. Many mentioned that nerves took over and they could not remember what they wanted to say and do. They also had problems keeping the talk "active" and moving between participants. In many instances, the lack of participation among participants led the leaders of the talk to begin reading the planning sheet to their groups.

SCAFFOLDS IMPLEMENTED

In an effort to support the growth of these EPSTs' discourse skills, several scaffolds were added to the existing assignment.

Modeling

It was decided we should model a "Science Talk" for our classes. Using a Page Keeley probe, we led the group in a discussion, drawing attention to how students were encouraged to explicate their reasoning, how student thinking was made visible, and how peer-peer interaction was encouraged.

Talk Moves

We also introduced EPSTs to "talk moves" which are pedagogical tools to foster productive discussions. We assigned readings and viewed two short Teaching Channel videos in which teachers used talk moves such as restating, re-voicing, and having students apply their own reasoning to their peers' responses.

Restructuring the Assignment

The assignment was restructured to include a discrepant event, model, or task students would use to gather data or make observations during the talk. We also posted a sample "Planning My Science Talk" assignment to demonstrate the breadth and depth we were expecting for this assignment.

Pre-conference

On the class date prior to the talk, we instituted a pre-conference with all facilitators. We provided some advice for leading successful talks, like having a bulleted list of talk moves and key questions rather than referring to their entire "Planning My Science Talk" document. We suggested EPSTs use whiteboards to write down student responses, draw representations, and emphasize key words and big ideas during the talk implementation. We also encouraged EPSTs to think of ways to make their peers' thinking visible including making models, requiring students to explain their reasoning, and using real-life examples to which students could relate.

Talk

One additional way we changed the format of the talk was to instruct students in each group to think and respond as elementary students. Our goal was to eliminate students' fears of being wrong in front of their peers and to encourage them to think as elementary students might approach the prompt.

DISCUSSION OF STUDENT REFLECTIONS

In our first round of science talks using the revised assignment and scaffolds, we noted several factors that promoted productive talk. We used student reflections as evidence of EPSTs' increased knowledge of effective implementation of science discourse, as well as areas that need improvement. Recurring themes in these reflections are noted below.

As evidenced by their reflections, there continues to be room for growth and improvement. Some EPSTs mentioned suggestions for facilitators, as did Jordan, stating many of the questions her facilitator asked were "yes or no questions that lead to dead-end answers." One facilitator commented after watching her video on asking leading questions, "I noticed I gave away the answers before asking the question, which limited responses." Some struggled with their ideas about the teacher's role in the talk, saying, "I asked the students questions and instead of promoting talk and letting them answer, I answered. For some reason, I felt like if I wasn't talking, I wasn't doing it right." These comments demonstrate that EPSTs are novices and recognize they need practice to develop their discourse skills.

Despite these struggles, student reflections cite tremendous growth in certain areas. Facilitators spoke of the importance of preparation, as did this EPST who said, "One thing I learned from the teaching aspect of this talk was you really need to understand background knowledge before teaching a subject … If I thought I knew what melting was and didn't read up on the subject, I wouldn't have been able to explain the difference between melting and dissolving." The ideas of constructivist teaching were made real as when one students stated, "Especially for science, I feel it is important to have an experiment available so one can physically see the difference between two common activities. If we would have just argued back and forth on why one feels they are the same, and another feels they are different, I might still be confused about what melting really is." Their comments pointed to the effectiveness of the scaffolds we provided, especially the incorporation of a task within the talk in which students gathered evidence to support their claims.

Another recurring theme in the reflections was EPSTs' perception of having learned from their peers. They mentioned learning science content, as evidenced by comments like, "Before this talk, I can honestly say I had no idea what the difference was between melting and dissolving." They also learned about leading discourse, "Before this, I would have had no idea how to lead a successful talk that kept students engaged in conversation. I am very thankful Sara did such a wonderful job with her science talk to give me an idea of how to lead one of my own."

Overwhelmingly, EPSTs commented in their reflections that they recognized specific talk moves their facilitators used. For example, one student commented, "Nicole used a lot of talk moves. For example, she made us restate what other students had previously said but in our own words." A fellow student noted, "The leader of my talk asked us why we agreed or disagreed and created a friendly debate between the group to engage us in the learning." And another stated, "Not only did she ask us for our answers, but she also asked why we came up with the answer we did." As evidenced by their comments, EPSTs now recognized "talk moves" and how they were used to promote discourse, and they felt better prepared to lead their own future discussions.

CONCLUSION

Through modeling and practicing science discourse, EPSTs have the opportunity to significantly develop this pedagogical skill while improving their content knowledge. We found EPSTs used and can identify such talk moves as restating, re-voicing, and peer-to-peer talk. From our experience, we discovered that EPSTs had similar struggles in facilitating discourse in such areas as asking thought-provoking questions, managing silence, and revealing too much information before asking questions, which limited participants' active engagement (Alexandra, 2006). When the talk became static, EPSTs stated that they felt that to be a successful teacher you should continue talking and at times this type of talk turned to defining vocabulary (Richardson-Bruna, et al., 2007). We found that EPSTs discovered the complexity and the multifaceted aspects of planning and leading science discourse. Through this experience, EPSTs stated the value and significance of this pedagogical tool. Based on the data collected in three semesters, this assignment with added scaffolds has shown promise in growing pre-service teachers' science content knowledge and the essential skill of leading classroom science discourse.

As of this fall semester (2016), the impact of the assignment and scaffolds has been extended beyond the science concentration students to include students in our elementary science methods courses. Many students successfully incorporated the assessment probes and "talk moves" within lessons they planned and taught. We plan to strengthen our research in the future to include an evaluation of content and discourse skills of elementary students based on the science talks assignment implementation in methods courses.

REFERENCES

Achieve (2013). *Next Generation Science Standards: For States, By States.* Washington, DC: The National Academies Press.

Alexander, R. J. (2006). Towards dialogic teaching (3rd ed.). York, UK: Dialogos.

Alexander, R. (2008). Towards dialogic teaching: Rethinking classroom talk (4th ed.). Cambridge: Dialogos.

Alexopoulou, E., & Driver, R. (1996, June 1). Small-group discussion in physics: Peer interaction modes in pairs and fours. *J. Res. Sci. Teaching, 33*(10), 1099-1114.

Bianchini, J. (1997). Where knowledge construction, equity, and context intersect: Student learning of science in small groups. Journal of Research of Science Teaching, 34(10), 1039-1065.

Duschl, R. (2008). Quality argumentation and epistemic criteria. In S. Erduran & M.-P. Jime´nez-Aleixandre (Eds.), Argumentation in science education: Perspectives from classroom-based research (pp. 159–175). Dordrecht, The Netherlands: Springer.

Keeley, P., Eberle, F., & Farrin, L. (2005). Uncovering Student Ideas in Science: 25 formative assessment probes. National Science Teachers Association Press. Volume 1.

Kelly, G., & Crawford, T. (1997). An ethnographic investigation of the discourse processes of school science. Science Education, 81(5), 533-559.

Kelly, G., & Green, K. (1998). The social nature of knowing: Toward a sociocultural perspective on conceptual change and knowledge construction. Perspectives on conceptual change: Multiple ways to understand knowing and learning in a complex world. pg. 145-181.

Kovalainen, M., & Kumpulainen, K. (2005). The discursive practice of participation in an elementary classroom community. Instructional Science, 33(3), 213–250.

Lehesvuori, S., Viiri, J., & Rasku-Puttonen, H. (2011). Introducing dialogic teaching to science student teachers. Journal of Science Teacher Education, 22(8), 705–727.

Linn, M. C., & Burbules, N. C. (1993). Construction of knowledge and group learning. In K. G. Tobin (Ed.), *The practice of constructivism in science education*, (pp. 91-119). Washington, DC: American Association for the Advancement of Science (AAAS) Press.

Lyle, S. (2008). Dialogic teaching: Discussing theoretical contexts and reviewing evidence from classroom practice. Language and Education, 23(3), 222–240.

Mercer, N. (2008). The seeds of time: Why classroom dialogue needs a temporal analysis. Journal of the Learning Sciences, 17(1), 33–59.

Molinari, L., & Mameli, C. (2010). Classroom dialogic discourse: An observational study. Procedia— Social and Behavioral Sciences, 2(2), 3857–3860.

National Research Council. (2007). Taking science to school: Learning and Teaching science in grades K–8. Washington, DC: The National Academies Press.

Richardson-Bruna, K., Vann, R., & Escudero, M. P. (2007). What's language got to do with it? A case study of academic language instruction in a high school "English Learner Science" class. Journal of English for Academic Purposes, 6, 36–54.

Richmond, G., & Striley, J. (1996). Making meaning in classrooms: Social processes in small-group discourse and scientific knowledge building. Journal of Research in Science Teach- ing, 33, 839–858.

Roth, W. M. (2008). The nature of scientific conceptions: A discursive psychological perspective. Educational Research Review, 3, 30–50.

Tobin, K. & Tippins, D. (1993). Constructivism as a referent for teaching and learning. In K. Tobin & D. Tippins (Eds.), The practice of constructivism in science education (pp. 3–22). Hillsdale, NJ: Erlbaum.

van Eijck, M., & Roth, W.-M. (2011). Cultural diversity in science education through novelization: Against the epicization of science and cultural centralization. Journal of Research in Science Teaching, 48, 824–847.

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