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Beginning Elementary Mathematics Teachers Negotiating Leadership Responsibilities

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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.

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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.

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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.

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Knowledge, Monitoring, and Beliefs:

A Comparative Analysis among Preservice Teachers from Three Different STEM-focused Programs

Margareta M. Thomson and John L. Nietfeld

Abstract: *In the current study, we investigated how preservice teachers (N = 242) from three different teacher-training programs with a STEM focus, namely the Elementary Education (ELM), Science Education, and Mathematics Education, compare with respect to science content knowledge, metacognitive monitoring, and their belief system. Findings revealed that the ELM preservice teachers reported higher levels of science reformed beliefs (e.g., constructivist instruction), but low science content knowledge and teaching efficacy beliefs. Alternatively, Science Education students exhibited the highest levels of content knowledge, accurate monitoring, and higher teaching efficacy beliefs. Implications for teacher education programs with a STEM training focus are discussed.*

Keywords: teacher preparation; content knowledge; monitoring, teacher beliefs.

Currently, there are many calls for action to prepare better teachers with strong content knowledge and reform oriented pedagogical skills (e.g., AACTE, 2007; NAS, 2006). National reports (i.e., NRC, 2011; NSTA, 2004) recommend that teacher training should emphasize inquiry-based learning that focuses on the active construction of knowledge through direct experience. Given the current emphasis on reformed science teaching it is important to ensure an alignment between teachers' reformed beliefs and practices, along with strong content knowledge, high efficacy and calibration, in order to provide support for reformed instructional practices (Schraw et al., 2006).

Research shows that teachers need well-developed content knowledge to successfully teach their students (Hill, Rowan, & Ball, 2005; Kennedy, Ahn, & Choi, 2008). Teachers' coursework during their teacher education program, in addition to teaching experience, are important factors in the development of teachers' content knowledge. In addition to having a rich, interconnected knowledge base it is important to have an accurate understanding of that knowledge. Monitoring accuracy has been linked to study processes, test performance and critical thinking, and is now gaining more attention in classrooms (Hacker, Dunlosky, & Graesser, 2009).

Along with content knowledge, teachers' beliefs have a strong influence on instructional decisions and classroom actions (i.e., Peters-Burton & Frazier, 2012). Often, teachers' beliefs are grounded in their personal and academic experiences, and can explain teachers' views of effective teaching and learning, and their classroom decisions (Sampson & Benton, 2006). Research shows that teachers' instructional beliefs, epistemological and efficacy beliefs have an influence on students' academic achievement (Schraw et al., 2006). Studies demonstrate a direct relationship between teachers' instructional beliefs and innovative instructional practices (Mansour, 2009; Richardson & Liang, 2008). Additionally, epistemological beliefs, along with teachers' self-efficacy beliefs appear to play an important role in teacher science learning and development, as well as a key role in student science achievement (Hechter, 2011; Schraw, Bendixen, & Dunkle, 2002).

Unfortunately, several studies point out that a large number of preservice teachers lack the necessary knowledge and skills to effectively manage their learning (i.e., Kramarski & Michalsky, 2009; Michalsky & Schecheter, 2013). This is extremely alarming when teachers are unable to see themselves as effective learners, do not know how to monitor their learning, and their beliefs do not align with reformed science teaching practices. The aim of the current study was to investigate how preservice teachers from three different STEM (Science, Technology, Engineering and Mathematics) teacher-training programs compare with respect to their content knowledge, monitoring accuracy and beliefs. These programmatic comparisons are necessary in order to fully understand differences and to address weaknesses in various teacher-training models.

Participants were from the Elementary Education (ELM), Science Education, and Mathematics Education programs. Specifically, we compared participants from these three programs with respect to their science content knowledge, monitoring accuracy and beliefs (i.e., beliefs about teaching and learning science, self-efficacy beliefs and epistemological beliefs). The research questions we addressed were the following:

1. How do ELM preservice teachers differ from their peers, Science and Mathematics Education preservice teachers with respect to their *science content knowledge* and *metacognitive monitoring accuracy*?

2. How do ELM preservice teachers differ from their peers, Science and Mathematics Education preservice teachers, with respect to their *beliefs* (i.e., science teaching and learning beliefs, efficacy beliefs and epistemological beliefs)?

3. What are the general relationships between preservice teachers' *science content knowledge*, *monitoring accuracy* and *beliefs*?

METHODS

Participants and Context

Participants for this study included 242 preservice teacher education students from a major research university in the Southeast of United States. Demographic data indicated that 201 were females and 41 were males. Also, 103 participants were from the ELM program, 58 from Science Education, and 81 from Mathematics Education. The bulk of the students were juniors (n = 105) and seniors (n = 80) but the sample also included 8 freshmen, 36 sophomores, and 13 students classified as "other."

All participants in this study were enrolled in a traditional teacher-training program (i.e., a four-year bachelor's degree) at a major research university, and their respective programs had a strong STEM focus. In the STEM-Elementary Education program preservice teachers are required to take a total of 27 credit hours in STEM content courses (including a minimum of 12 hours in mathematics and 12 in science). Students in the Science Education program complete a total of 13 credit hours in mathematics and science; 6 credit hours are allocated for mathematical science courses and 7 credit hours for natural sciences. Students in the Mathematics Education program complete a total of 13 credit hours in general mathematics and science; 6 credit hours are allocated for mathematical science courses and 7 credit hours for natural sciences.

Procedure and Materials

Quantitative data measuring science content knowledge and beliefs (i.e., reformed science beliefs, efficacy and epistemological) were collected in the current study using a survey. All participants (N = 242) were enrolled at the time of data collection in methods courses specific to their teacher education program. The survey consisted in a science content knowledge test and beliefs inventories, all administered in one session. There was a 20-minute time limit for the content knowledge test and no time limits on the beliefs inventories. A summary of measures is presented in Appendix A.

RESULTS AND DISCUSSION

Descriptive statistics for major study variables can be found in Appendix B. The results described in this section are organized according to the primary research questions.

Differences in Content Knowledge and Monitoring Accuracy

A 3 (groups) x 4 (content knowledge and monitoring judgments) MANOVA was conducted to investigate differences between the ELM, Science Education, and Mathematics Education preservice teachers with regard to science content knowledge, confidence estimates, calibration, and response bias. A multivariate main effect for group, Pillai's trace, $V = .24$, $F(6, 456) = 10.51$, $p < .001$, was accompanied by significant univariate effects for all four dependent measures: content knowledge, $F(2, 229) = 78.96$, $p < .001$, ηp2 = .10, confidence, $F(2, 229) = 22.13$, $p < .001$, ηp2 = .16, calibration, $F(2, 229) = 11.60$, $p < .001$, ηp2 = .09, and response bias, $F(2, 229) = 10.17$, $p < .001$, ηp2 = .08.

Pairwise comparisons for science content knowledge revealed that the ELM preservice teachers scored significantly lower than both the Science ($p < .001$) and Mathematics preservice teachers ($p = .009$). However, no significant differences were found between the Science and Mathematics preservice teachers ($p = .118$). Pairwise comparisons for confidence indicated that the ELM preservice teachers had significantly lower confidence judgments than Science preservice teachers ($p < .001$) but not Mathematics preservice teachers ($p = 1.000$). Moreover, the Science preservice teachers had significantly higher confidence estimates than the Mathematics preservice students ($p < .001$). Pairwise comparisons for calibration revealed that the Science preservice students were significantly more calibrated than both the ELM preservice teachers ($p = .002$) and the Mathematics preservice teachers ($p < .001$). No differences were found between the ELM and Mathematics preservice teachers ($p = .325$). Pairwise comparisons for response bias revealed that the ELM preservice teachers were significantly different than both the Science ($p = .046$) and the Mathematics preservice teachers ($p = .045$). In addition, the Science preservice teachers were significantly different than the Mathematics preservice teachers ($p < .001$). Both the ELM and Mathematics preservice teachers were under confident as a whole in their judgments, with Mathematics preservice teachers being more extreme in their response bias. Science preservice teachers, on the other hand, had average scores that tended toward an overconfident response bias.

Differences in Teaching Beliefs

A 3 (groups) x 3 (beliefs measures) MANOVA was conducted to investigate differences between the ELM, Science Education, and Mathematics Education preservice teachers with regard to beliefs about reformed science teaching (BARSTL instrument), science efficacy (STEBI) and epistemological beliefs (EBI). A multivariate main effect for group, Pillai's trace,

$V = .90$, $F(6, 470) = 64.65$, $p < .001$, was accompanied by significant univariate effects for the BARSTL, $F(2, 236) = 44.75$, $p < .001$, ηp2 = .28, STEBI, $F(2, 236) = 259.48$, $p < .001$, ηp2 = .69, and the EBI, $F(2, 236) = 40.09$, $p < .001$, ηp2 = .25.

Pairwise comparisons for participants' scores on their beliefs about reformed science teaching and learning inventory (BARSTL) revealed that ELM preservice teachers scored significantly higher than both the Science ($p < .001$) and Mathematics preservice teachers ($p < .001$), suggesting that ELM students held more reformed beliefs about science teaching and learning than their Science and Mathematics Education peers. However, no significant differences were found between the Science Education and Mathematics Education preservice teachers ($p = .375$).

Pairwise comparisons for participants' scores on their self-efficacy beliefs for science teaching efficacy inventory (STEBI) indicated that the ELM preservice teachers had significantly lower self-efficacy for teaching science than both the Science ($p < .001$) and the Mathematics preservice teachers ($p = .004$).

Moreover, the Science preservice teachers scored significantly higher than the Mathematics peers ($p < .001$).

Pairwise comparisons for participants' scores on their epistemological beliefs inventory (EBI) revealed that the Science preservice teachers had lower scores than both the ELM preservice teachers ($p < .001$) and the Mathematics preservice teachers ($p < .001$), suggesting that Science preservice teachers held more sophisticated epistemological beliefs compared to their ELM and Mathematics preservice teachers. No differences were found between the ELM and Mathematics preservice teachers ($p = .338$) with respect to their epistemological beliefs.

With regard to the epistemological world view (EWV) inventory ANOVA procedures revealed that the three groups of preservice teachers differed significantly only on the first vignette illustrating the realist world view $F(2, 239) = 6.63$, $p = .002$, $\eta p2 = .05$, as the ELM preservice teachers ($M = 2.75$) scored significantly lower than both the Science ($M = 3.21$, $p = .029$) and the Mathematics preservice teachers ($M = 3.30$, $p = .002$). However, no significant differences were found between the Science and Mathematics preservice teachers ($p = .882$) with respect to their scores on the epistemological world view inventory.

General Relationships

Correlations between content knowledge, metacognitive judgments, and beliefs variables are presented in Appendix C. Science content knowledge is significantly related to each of the other six variables with the exception of the reformed science beliefs inventory (BARSTL). Preservice teachers in our sample with higher content knowledge also tended to make more confident judgments, were more accurate in their judgments, and also tended to be more under confident. These students also tended to have higher teaching efficacy and reported to have more complex epistemological beliefs.

CONCLUSION

Study results show that Science Education preservice teachers in the current study exhibited higher levels of science content knowledge, more confidence and more accurate monitoring of that knowledge, and higher levels of science teaching efficacy than ELM preservice teachers. The ELM preservice teachers reported lower science content knowledge and efficacy, but higher levels of reformed beliefs than both Science and Mathematics preservice teachers. Such results might indicate the intense exposure of the ELM preservice teachers to science teaching reform orientations and educational theories that support constructivist approaches to teaching and student-centered instruction. This is not surprising given the fact that K-5 teaching is more oriented towards a student-centered approach and is focused on collaborative, constructivist learning (Poon et al., 2012).

Within group comparisons analysis regarding participants' epistemological world views showed that all three groups of preservice teachers favored the contextualist perspective on teaching (i.e., knowledge is constructed, has authentic applications, and is changeable) over the realist perspective (i.e., knowledge is fixed and unchangeable) or relativist perspective (i.e., knowledge is constructed and is subjective). So, when given the option, most participants did choose an epistemological perspective that aligns with more contemporary reform movements in science education, such as adopting a constructivist perspective in teaching, inquiry-based learning and student-centered instruction. These findings have implications for teacher education, considering that research shows that students with less sophisticated epistemological beliefs generally achieve less than students with more complex, sophisticated epistemological beliefs, even when other variables are constant (Schommer-Aikins, 2002).

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Appendix A

Measures and data sources

Instruments/Measures	**Short Description**
*Science Knowledge Test (*SKT, Thomson & Nietfeld, 2016)	SKT is a 20-item, four-option multiple-choice test of science knowledge drawn from practice items for the Biology and General Science *Praxis II* test. The overall mean for the test was 12.34 (*SD* = 2.69, α = .56).
Beliefs about Reformed Science Teaching and Learning (BARSTL, Sampson & Benton, 2006)	BARSTL is a 24-item inventory (5-point Likert scale) measuring beliefs about science reform in four categories: *how people learn about science*, *lesson design and implementation*, *characteristics of teachers and the learning environment*, and *the nature of the science curriculum*. A total sum score across the four categories was used in the analysis (α = .70).
Science Teaching Efficacy Beliefs (STEBI, Enochs & Riggs, 1990)	STEBI is a 23-item inventory to measure *personal teaching efficacy* and *outcome expectancy* for teaching science. The 13 items under *personal teaching efficacy* (five-point Likert scale) were used in this study. A sum score was created across the 13 items for the analysis (α = .83).
Epistemic Beliefs Inventory (EBI, Schraw, Bendixen, & Dunkle, 2002)	EBI is a 32-item inventory to measure five different factors regarding the nature of knowledge and the origins of individuals' abilities. The factors include *certain knowledge* (i.e., absolute knowledge exists and will eventually be known), *simple knowledge* (i.e., knowledge consists of discrete facts), *omniscient authority* (i.e., authorities have access to otherwise inaccessible knowledge), for *quick learning* (i.e., learning occurs in a quick or not-at-all fashion), and for *fixed ability* (i.e., the ability to acquire knowledge is fixed). A total sum score was calculated (α = .67) including items (26 total) from all 5 subscales. Higher scores represented less complex views (i.e., beliefs in simple knowledge).
Epistemological World View (EWV, Schraw & Olafson, 2002)	EWV is comprised of three vignettes (one paragraph each) that represent *realist*, *relativist*, and *contextualist* perspectives on learning science. Respondents were asked to report the extent to which they agree with each perspective on a 5-point Likert scale.
Monitoring Accuracy (MA)	MA was measured as part of the science knowledge test. During the science knowledge test participants placed a slash along a 100mm line to indicate confidence in their answer (Schraw & Roedel, 1994). Metacognitive monitoring ability was then calculated with two indices (Schraw, 2009) namely 1) *calibration* (precision of judgments) and 2) *response bias* (the degree of over- or under-confidence in judgments). A calibration score of 0 is perfect accuracy while a score of 1 is perfect inaccuracy (Keren, 1991). Bias, the extent of over or underconfidence, was determined by subtracting the overall performance score (exam percentage) from the average of all confidence judgments. Positive scores indicate overconfidence and negative scores indicate underconfidence (Yates, 1990).

Appendix B

Means and standard deviations of study variables

Group	Science knowledge *M/(SD)*	Science Confidence *M/(SD)*	Science Calibration *M/(SD)*	Science Bias *M/(SD)*	Beliefs about Science Teaching *M/(SD)*	Science Teaching Efficacy *M/(SD)*	Epistemic Beliefs *M/(SD)*
ELM	11.46 (2.54)	54.50 (15.30)	.35 (.07)	-.03 (.14)	85.37 (7.55)	37.25 (3.59)	69.27 (6.96)
SE	13.55 (2.34)	71.19 (15.31)	.31 (.08)	.03 (.15)	76.59 (5.65)	53.47 (5.89)	60.39 (7.53)
ME	12.54 (2.76)	54.44 (18.64)	.37 (.09)	-.09 (.18)	78.22 (4.99)	39.38 (4.26)	71.14 (7.30)
Total	12.34 (2.69)	58.61 (17.96)	.35 (.09)	-.03 (.16)	80.87 (7.44)	41.87 (7.97)	67.80 (8.32)

Note. Confidence scores represent average judgments per item. Lower epistemic beliefs scores represent views that are more complex.

ELM=Elementary Education; SE=Science Education; ME=Mathematics Education

Appendix C

Correlations between major study variables

	Measure	1	2	3	4	5	6	7
1	SKT	----	.48**	-.32**	-.27**	-.02	.22**	-.13*
2	Confidence		----	-.48**	.71**	-.01	.34**	-.20**
3	Calibration			----	-.27**	-.09	-.21**	.12
4	Response Bias				----	.01	.20**	-.11
5	BARSTL					----	-.32**	-.06
6	STEBI						----	-.36**
7	EBI							----

* $p < .05$, ** $p < .01$.

SKT=Science Knowledge Test (science content knowledge); BARSTL= Beliefs about Reformed Science Teaching and Learning; STEBI=Science Teaching Efficacy Beliefs Inventory; EBI=Epistemological Beliefs Inventory.

Out of School and into STEM:
Supporting Girls of Color Through Culturally Relevant Enrichment

Jemimah L. Young, Jamaal R. Young, Noelle A. Paufler

Abstract: *Increasing the participation of girls of color in Science, Technology, Engineering, and Mathematics (STEM) is a national concern. Due to the persistence of achievement and opportunity gaps, sustaining positive STEM dispositions in girls of color is critical to diversifying the STEM pipeline. Enrichment activities can serve as a means to address persistent gaps in opportunities to learn. The purpose of this article is to explain how teachers can adapt traditional STEM enrichment activities to support girls of color through culturally relevant instructional practices. The three components of culturally relevant pedagogy are utilized to demonstrate how traditional activities can be adapted to support girls of color in STEM. Presented here are examples to foster (1) academic success, (2) cultural competence, and (3) sociopolitical consciousness in girls of color. Both pre-and in-service teachers who desire to serve as teacher leaders in STEM need greater opportunities for STEM professional development, especially those that help teachers build upon culturally relevant teaching. Implications and suggestions for teacher leaders are given throughout.*

Keywords: Out of School Time, STEM, girls of color, culturally relevant teaching

Increasing the participation of girls of color in Science Technology Engineering and Mathematics (STEM) is a national concern. Projections suggest that the proportion of underrepresented people of color in science and engineering would need to triple to match their proportions in the U.S. population (Schneider, Judy, & Mazuca, 2012). Promoting STEM career interests for a more diverse population of learners is a major goal of U.S. educational policy. Access to, and participation in STEM enrichment is one way to increase STEM career interest. STEM enrichment has two primary benefits for traditionally marginalized populations.

First, participation in authentic applications of STEM through projects promotes interest in science and mathematics careers (Rukavina, Zuvic-Butorac, Ledic, Milotic, & Jurdana-Sepic, 2012). Due to differences in opportunities to learn, educational outcomes vary by educational settings and resource availability (Bell, Bricker, Reeve, Zimmerman, & Tzou, 2013). Hence, enrichment activities can serve as a means to address persistent gaps in opportunities to learn. The purpose of this article is to explain how teachers can adapt traditional STEM enrichment activities to support girls of color through culturally relevant instructional practices.

BACKGROUND

Gender and racial disparities are prevalent in STEM professions. Women hold approximately half of all jobs in the U.S. economy; however, they hold disproportionately fewer STEM degrees than their male counterparts and fill less than 25% of all STEM jobs (e.g., engineering) (Beede et al., 2011). Additionally, women who hold STEM degrees are more likely to work in fields such as education and healthcare (University of Sciences, 2012). Research suggests that gender disparities in STEM interest and achievement among students have narrowed significantly (Choi & Chang, 2011; Shapiro & Williams, 2012). Trends suggest that achievement differences have lessened across course taking, as well as content knowledge.

Girls in high school attempt a similar number of advanced mathematics courses as boys and those in grades two to eleven (i.e., grade levels most commonly tested via large-scale state standardized assessments) exhibit mathematics ability similar to that of boys on observed assessments (Hyde, Lindberg, Linn, Ellis, & Williams, 2008). Correspondingly, Quinn and Lyons (2011) found no difference in science engagement between boys and girls, while others suggest that the science gender gap is a reflection of perceptions rather than ability (Knezek, Christensen, & Tyler-Wood, 2011). Unfortunately, racial achievement gaps remain, most notably between Black and Hispanic students and their White counterparts (Riegle-Crumb, Moore, & Ramos-Wada, 2011). To redress these inequities, it is important that teachers lead the charge in STEM success for girls of color.

DEVELOPING TEACHERS AS LEADERS IN STEM SUCCESS

STEM success for all begins in the classroom. According to Beier and Rittmayer (2008), teachers must recognize and reward achievement in STEM in order to foster positive STEM dispositions. Students who are STEM proficient and active in advanced courses are more likely to pursue STEM degrees (Sahin, Erdogan, Morgan, Capraro, & Capraro, 2013; Wang, 2012). Classroom experiences can foster these positive experiences (Aschbacher, Li, & Roth, 2010; Scantlebury, 2014). Teachers must provide instruction that supports knowledge building in K-12 and postsecondary classrooms (Lichtenberger & George-Jackson, 2013). These more general strategies provide support to all learners, but due to the persistence of dual marginalization based on race and gender, girls of color require additional classroom considerations.

Although research for, and support of, STEM teaching has increased and has far greater potential to benefit students, particularly girls of color, challenges still exist in recruiting and retaining high-quality teaching staff, maintaining funding, and making connections to formal learning standards (Dyer, 2004). High-quality teachers need adequate background knowledge, confidence, and efficacy for teaching STEM in order to be effective (Nadelson et al., 2013). In order to become more confident and effective teacher leaders in STEM, many teachers, especially at the elementary level, would benefit from opportunities to expand their content knowledge and engage in ongoing professional development training (NRC, 2011). Teachers who have strong STEM content knowledge and effective pedagogical skills are better prepared to be teacher leaders in STEM. Thus, teachers should receive STEM-specific instruction and mentoring that is relevant to their instructional practices and individual needs in STEM professional development training (NRC, 2011; Smith & Neale, 1991).

For example, Nadelson et al. (2013) examined the impact of attending a three-day summer institute designed to increase teachers' confidence, efficacy, content knowledge, and awareness of STEM professionals and careers. They found that the institute had a significant positive influence on teacher participants' efficacy for teaching STEM, confidence for teaching STEM, and attitudes toward engineering (Nadelson et al., 2013). Lotter, Smiley, Thompson, and Dickenson (2016) also found that middle school teachers who attended professional development over a three-year period (summer and school year) that focused on inquiry pedagogy and science content had statistically significant increases in the quality of their instruction, as well as in their self-efficacy for teaching through inquiry.

To help girls of color understand practices, concepts, and core ideas, teachers need to not only have the prerequisite content knowledge, but also be able to recognize students' diverse backgrounds and utilize instructional strategies to facilitate learning (Rivet & Krajcik, 2008). Focused preparation and ongoing professional training can help teachers develop the necessary content knowledge that contributes to self-efficacy (Schoon & Boone, 1998). The section that follows provides a discussion of how STEM enrichment can redress student negative experiences and low teacher self-efficacy.

TEACHER LED CULTURALLY RELEVANT STEM ENRICHMENT

Teacher led culturally relevant Out of School Time (OST) STEM activities have practical as well as educative merit. Opportunities to pursue STEM interests are not available in all schools, thus OST helps to address the opportunity gap (Woolley et al., 2010). STEM-related interests and aspirations for girls of color emerge early (Watt & Eccles,

2008) and, as Young points out (Young, 2017), culturally relevant, gender specific STEM promotes and sustains positive STEM dispositions in girls of color. Hence, exposure to high-quality culturally relevant STEM instruction through OST activities is pivotal to developing and sustaining positive STEM dispositions amongst girls of color. The three components of culturally relevant pedagogy are present in the examples that follow:

1) Academic success;
2) Cultural competence; and
3) Sociopolitical consciousness.

Additionally, these examples are tailored to meet the unique learning needs of girls of color.

ACADEMIC SUCCESS

Success begets success, thus culturally relevant OST activities should promote academic achievement through productive struggle and opportunities to succeed. When appropriately executed, STEM OST engages youth in rigorous high-quality activities (Gupta, Adams, & Dierking, 2011; Vandell, Simzar, O'Cadiz, & Hall, 2016; Young, Ortiz, & Young, 2017). To support the learning needs of girls of color, teachers should create activities that support the "productive struggle". The "productive struggle" is an academic process that yields deeper conceptual understanding when a student's prior knowledge is insufficient to understand or address the given problem, or the student is unable to assimilate new information and thus struggles to complete the task.

Deeper learning occurs because the student is forced to reexamine, restructure what is already known in order to solve an unfamiliar problem (Hiebert & Grouws, 2007). This process helps students to correct and reconstruct prior knowledge, and construct new knowledge (Granberg, 2016). The productive struggle is the measured amount of academic frustration and rigor necessary to build resilience without destroying student self-efficacy. Thus, activities should be assessed using rubrics that incorporate multiple criteria for academic success.

CULTURAL COMPETENCE

OST programs provide valuable experiences that foster interest and help students realize how STEM connects to everyday experiences (Thomasian, 2011). OST provides exposure to learning experiences that can be impractical in many traditional school settings. For example, STEM enrichment affords students opportunities to reinforce practical connections by visiting museums and STEM-related businesses (Morana, Bombardier, Ippolito, & Wyndrum, 2012).

These visits however must be purposeful in order to bring STEM to life. Girls of color should be encouraged to identify the unique contributions of women of color to the exhibits and products presented during these interactions. For example, until their recent depiction in the movie "Hidden Figures" the contributions of Mary Jackson, Katherine Johnson, and Dorothy Vaughan have been absent from the mainstream history of NASA. Girls should be required to conduct research before visiting museums or businesses to uncover similar contributions from women of color. Uncovering and reporting the absence of these stories empowers girls of color by providing STEM related ethnically and gender matched aspirational role models.

Girls should be exposed to experiences that explicitly and tangentially reflect their cultural funds of knowledge. This can be accomplished by soliciting female engineers of color as guest speakers or mentors. According to Weber (2011), female university students, faculty, and alumni can serve as role models for girls in elementary and secondary schools by engaging in OST activities such as visits, guest lectures, after-school and summer programs, etc. Interactions with positive female role models in the scientific community can encourage girls to pursue their interest in STEM at the university level (Austin & Sax, 2006; National Research Council (NRC), 2006). This is important because girls of color are especially underrepresented in science.

SOCIOPOLITICAL CONSCIOUSNESS

Often women of color avoid STEM careers because of the lack of explicit opportunities to serve their community; they tend to not be exclusively driven by the financial gains of the profession (Ellington & Frederick, 2010). However, by promoting social consciousness through culturally relevant pedagogy, girls of color may reconsider STEM careers. Thus, culturally relevant STEM activities should have a community focus (Young, Young, & Hamilton, 2013). For example, activities like designing a new playground for the local neighborhood would allow older girls to give back to their community schools. Alternatively, girls could research a social or health crisis that is prevalent in their community and then create a public awareness campaign. They could also investigate the science behind childhood obesity, diabetes, or other issues affecting their community and work toward solutions.

CONCLUSION

Women of color represent a proportion of diverse learners that remain underrepresented in STEM professions. The absence of women of color in STEM fields is a national concern (Hill, Corbett, & St. Rose, 2010). Women are represented in 50% of the U.S. jobs but hold less than 25% of STEM jobs (Bean et al., 2014). When categorizing data by race and gender, it becomes apparent that women of color are grossly underrepresented (Larke, Webb-Hasan, & Young, 2017).

Specifically, women of color represent only 10% of the professional STEM workforce (Feller, 2012). This suggests that women have experienced advances in STEM access; however, women of color remain particularly underrepresented in STEM professions. In conclusion, we propose that teachers begin to consider the effect of culturally relevant STEM to support girls of color in OST activities.

Teachers as leaders have a participatory obligation to support all learners, and in the essence of equity, it is important that teachers are attentive to the traditionally marginalized. It is our hope that teachers currently leading afterschool clubs and competitions will consider making these spaces more culturally relevant to support the access and achievement of girls of color. Strong teacher leaders can advance this cause by mentoring their peers and facilitating professional development trainings that are applicable to STEM OST activities. Greater opportunities for STEM professional development, especially those that help teachers build upon culturally relevant teaching, are needed for both pre- and in-service teachers who desire to serve as teacher leaders in STEM.

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Perspective

When STEM Leads to the Rest: A Reflection on STEM as the Hub for Curriculum Integration

Doug Price

Growing up, I experienced education as a world of silos. Language Arts (ELA) was where reading and writing occurred; Math held formulas and algorithms to solve equations; Drama served as an outlet for performance. Few overlaps existed in my mind: Science and Math spoke a shared language, and ELA held a leveled partnership with the Fine Arts. When I entered the field of education as a college student, the concept of interdisciplinary studies for K-12 education was scarcely discussed. It was not until my fourth year of teaching that the verbiage of STEM was specifically used in educational vernacular. I found it a fascinating idea and took to fine-tuning my craft; intentionally working to merge subject areas, causing them to crossover and intersect with one another.

Fast forward to my fifth year of teaching when I was presented an opportunity that seemed daring and innovative. I was asked to teach a class titled Core Connections (CC). The premise of the class is simple: the teacher of CC partners with the four core educators of a specific grade-level to create an intense interdisciplinary environment that forces students to dig deeper into content strands using Project-Based Learning (PBL) and STEM as the form of content delivery. I am now in my fifth year in CC and have seen how this pedagogical approach has challenged students. I have witnessed how students have come to understand that classes do not have to be separated into silos, but can be blended for deeper comprehension.

Although the specific projects and the content standards have varied from year-to-year, the learning that takes place consistently affirms that STEM is an effective hub for connecting other subjects. One might struggle to understand how ELA and Social Studies (SS) fit into the STEM mix but, in the following, I hope to demonstrate how these subjects logically intersect with each other and encourage educators to consider how their classes can contribute to, or derive from, STEM initiatives.

Using my own classroom setting — sixth grade Core Connections — I focus on three primary content areas: ELA, SS, and Fine Arts (i.e. music, dramatic arts, visual arts, etc.). I teach CC five times per day in 50-minute increments; and in this discussion, I reference the projects delivered in this specific setting. I will show how educators can move beyond rudimentary delivery of content to something more enriching for students.

LANGUAGE ARTS IN STEM

At the beginning of each school year, students embark upon one of two team-building projects: The Bridge Project and the Earthquake Project. In both instances, students divide into teams of three to five to build a structure: a bridge or a building. All teams have the same end goal — to build a durable structure that resists damage. A team's bridge should withstand more weight than those built by the other teams, and buildings should remain standing after a mock-earthquake. Materials for the two challenges are different, but the STEM programming remains the same.

In each project, students must explore the science behind each type of structure. Understanding concepts such as trusses, base isolators, or interactions between weight and mass forces them to take an in-depth look at the physics involved in each. Students typically accomplish this through reading assignments from informational texts, hands-on experiments, and open-class conversations. In addition, they must study the mathematical components of these structures, researching and experimenting with geometric figures to engineer the desired stability. Throughout these projects, students utilize technology in a number of ways ranging from conducting research online, to using alternative materials in the development of their structures (i.e. Popsicle sticks, gummy savers). While research and note taking are indeed part of this work, students are also expected to move into more advanced ELA assignments.

Communication is at the heart of ELA and some of the most intensive work that students produce while working on their projects grows out of an authentic need to communicate. Each team of three to five is composed of students from across the five class periods that I teach. This creates an immediate "problem" for the students to address; "If I cannot physically see or speak to my partners in class, and my team has to accomplish a common goal, how do I communicate with my teammates?" The presentation of this problem forces students to contemplate what the ideal solution would be. Most students come to recognize that a live-journal — a working journal that uses an internet based storage system to store student daily entries (such as Google Docs) — is best for this purpose. For six weeks, students engage in written dialogue with their teammates by maintaining this journal. A series of daily questions guide students in the argumentative writing phase, allowing them to tap into their understanding of scientific and mathematical concepts to support their hypotheses about the next steps in the building process.

In a project later in the year, students participate in the narrative writing process, creating a fictional world based on scientific observations. The end goal is for students to develop a children's book based on a scientific concept that they are learning in science class. The subject one year was their community garden, in another year it was their study of space. In both, students were immersed in an extensive research process and encountered explicit informational or technical text that improved their scientific comprehension. The in-depth research helps them accurately reflect the fictional world they are seeking to create. Once they have developed a more accurate setting for their story, they then undertake the narrative structures of fiction in the writing process.

ELA educators seeking to develop a cross-disciplinary curriculum will appreciate the way in which STEM organically connects to the writing process. Students can create arguments related to their hypotheses, practice expository and explanatory writing, and research a problem they uncovered or establish a fictional narrative that uses science as a foundation for story development. When integrating subject areas in this way, it is important to consider the academic standards for those other disciplines, which can be a challenge when moving into unfamiliar content areas. These strategies that bring together ELA and STEM disciplines help students to become proficient in [interacting] with complex informational texts in a variety of content areas (DeBoer, et al, 2012).

In developing these projects for my students, I am reminded of my 10th grade Biology class when I was asked to create and maintain an ecosystem for nine weeks. In this project, we kept a journal twice a week, marking any changes we saw, along with our hypothesis. I vividly remember the project. My partner and I included several types of lifeforms within the ecosystem, such as tadpoles and small fish. The journal I also remember, because we only had the first five minutes of class to write our observations. In challenging myself as an educator to implement an interdisciplinary curriculum, I have to wonder how authentic that ecosystem journal could have become had my teacher been more thoughtful about the writing component. The only effort that I gave to my journal was just enough to get the grade. In comparison, the writing assignments in the journals that my students keep for their bridge/earthquake projects has a specific intent. Our class spends the first week looking at a cost analysis of what happens when someone does not pull their weight in their journal entries. We hypothesize and discuss multiple issues: What happens when I skip my journal entry? What happens when I do not use the correct terminologies? What happens when I am not specific enough in my writing? The integration of ELA with STEM gives an added weight to assignments that helps students see the value in their work and connect it to real-world concepts.

SOCIAL STUDIES IN STEM

In my eight years of teaching, I have come to realize there is no core content area more overlooked than SS. It is dramatically underplayed in the interdisciplinary work of PBL even though, as Blanchette points out, it belongs on the same level with literacy and STEM (2012). SS plays a vital role in developing well-rounded students and employs history as a backdrop for demonstrating how citizenship shapes our world. History can inform students in ways that help them become empowered, active citizens. In an interview conducted by a team led by Dr. Brad Maguth of the University of Akron, a teacher named Mark Jones states: "[SS] is really the glue that holds all the individual STEMs together." He goes on to say that there are a lot of ethical and critical questions that need to be asked about [STEM]...It's dangerous to have discreet knowledge without the critical thinking or decision making skills established through the study of SS" (Maguth, 2012).

Toward the end of the school year, my students complete a project in which they hypothetically colonize an area of space. Students use scientific research and data to inform their decisions about where to colonize, and how to engineer a new piece of technology that is vital to their planet. They also utilize mathematical graphs and statistics to give their consumers an easy guide for understanding how resources are broken down in the new colony. As a part of the colony project, students reflect upon previous ancient history lessons about developing societies and consider what type of government they will enact in this new colony. They must then justify their choice of government to the potential constituents. SS and its significance to a fast-paced society has never been more critical than it is now in the 21st Century. SS, perhaps more than any other of the K-12 content areas, addresses the moral responsibilities of citizens and can provide the social contexts that help students understand STEM issues.

THE ARTS IN STEM

I would be remiss if I did not address the essential role that the Arts play in STEM-based education delivery models. It is time to move beyond the idea of visual art as just a dance or an illustration on canvas. I propose we begin to look at the Arts as a Science. Similar to Science, the Arts allow students the benefit of exploration, creation, failure, and success while, as Hendricks points out, giving them the independence to stretch their creativity (2016). Although it might be easy to say that a student who draws up a blueprint and engineers a building is showing how STEM connects with the Arts, there is far more to the Arts than pencil on graph paper (Schwartz, 2015).

To illustrate, another assignment that I have my students complete is entitled the "Play Project." In this project, students take on a topic that they have discussed in science class and work to answer an essential question related to that topic. Students address these questions through plays that they write and perform. In doing so, they come to see the importance of knowing and understanding the information. The process of writing the play requires that they comprehend the relevant scientific issues. The students employ math and engineering skills as they become their own theatrical troupe and create the different materials they will need (sets, costumes, props, etc.) all in the interest of enhancing the delivery of their plays.

The Arts also hold sway in one area that most other content areas may not, that of emotional investment (Hendricks, 2016). The Play Project demonstrates this in the way that it elicits emotional buy-in on the part of the students. As they do the research, participate in the writing and editing process, and build their comprehension of the STEM content, they recognize that the emotional connection they have for the subject is a result of personal investment in the work.

The Arts also have the capacity to inspire curiosity in math and science among students who typically shy away from STEM. When we forego including the Arts in an educational delivery model for STEM initiatives, we unintentionally segregate those students whose academic leanings are not toward science or math, ultimately leaving it to the student to determine whether they love or hate math and science practices (Edutopia, 2015).

CONCLUSION

STEM can be a natural integrator and motivator of all school subjects, and serve to eliminate the disciplinary silos that have been part of our educational tradition. It can also be a catalyst for the kind of deep intellectual engagement that leads to academic success. I urge us as educators to use STEM as an integrating hub that helps students see the connections between subjects, and recognize how they are relevant to the world we live in.

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Book Review

Dive Into Inquiry

MacKenzie, T. (2016.) Dive into inquiry. Irvine, California: EdTechTeam Press.

Amanda R. Casto

INTRODUCTION

Dive into Inquiry, by Trevor MacKenzie, explores the pedagogical methods of implementing student-driven inquiry in the classroom. Specifically, the author defines Four Pillars of Inquiry and four methods of engaging students in this specific approach to teaching and learning. MacKenzie, a high school teacher, wrote this book after spending seven years modifying and adapting the inquiry process for his students. What he learned during that time has been captured in this resourceful text of strategies and advice for other educators who are also venturing into the world of inquiry-based learning.

When teachers encounter obstacles in the classroom, they commonly ask the same questions that MacKenzie poses in his book: *"Am I doing enough? Am I doing it right? What can I change?"* Asking these questions caused the author to take a step back from his teacher-centered ways and experiment with teaching inquiry-based lessons to engage more of his high school English class students, including his most at-risk learners. Instead of pressing students to read outdated and seemingly irrelevant literature that caused them to immediately disengage; he discovered that letting their individual passions and curiosities drive the lessons had a greater educational impact. "Because students are genuinely excited to take ownership of their course, their energy is evident in their presentations and helps build a common trust, leading to an exceptionally strong learning community supporting inquiry," (MacKenzie, 2016, p.16). This discovery ultimately led to MacKenzie's decision to shift his teaching practices from teacher-centered to completely student-driven.

To begin shifting his teaching practices, MacKenzie employed help from his students to define "good teaching." After collecting an emphatic list of traits that his students believed to fully embody the phrase, he set out to change his pedagogical practices. The author describes the changes he made including relinquishing the control of the learning process to his students, creating opportunities to build relationships with each learner, and modifying the pattern of creating lessons. After several years of studying, categorizing, and fine-tuning student-led inquiry lessons, the author developed the four Types of Student Inquiry. These Types of Student Inquiry vary in degrees of teacher involvement and direction; for example, Structured Inquiry involves the class collaborating in one inquiry under the lead of the teacher, whereas Free Inquiry allows students to take the lead in learning about a topic of their own interest with less direct instruction and more support by the teacher. In addition to defining each Type of Student Inquiry, the author also provides detailed descriptions, student examples, and illustrations that fully encapsulate each inquiry method.

STYLE AND PURPOSE

Dive into Inquiry is broken into 20 manageable chapters. The content of this book is arranged in an organized and succinct manner, making it easy for classroom teachers to reference while planning inquiry units. In the first four chapters, MacKenzie establishes the argument for integrating inquiry-based lessons and units into a teacher's curriculum. In Chapter 5, *Types of Student Inquiry*, the author introduces his four methods of teaching using inquiry: Structured Inquiry, Controlled Inquiry, Guided Inquiry, and Free Inquiry. The following chapters then delve into the components and pillars of best practices in inquiry-driven lessons.

While reviewing the text, the reader may notice that significant quotes and facts from the literature are embellished in a larger font followed by the social media hashtag, #DiveintoInquiry. These quotes serve as a clever technique used by MacKenzie to carry the conversation of student inquiry with his readers over onto social media sites such as Twitter.

Dive into Inquiry is a useful and practical resource for educators, especially school administrators and classroom teachers. Principals who are eager to advance the levels of inquiry-driven instruction in their schools may find it a perfect fit for introducing their faculty to the inquiry-based learning process. This text is naturally broken into conveniently short sections, which provides many opportunities for reflection and discourse among teachers. This structure makes it ideal for use in professional learning communities or as a guide for instructional coaches.

Whether *Dive into Inquiry* is read collaboratively or independently, teachers who are ready to relinquish more control and responsibility to their learners will find this book to be interesting and relevant. Although the Types of Student Inquiry examples given are at the high-school level, MacKenzie argues that inquiry-based learning should begin as early as kindergarten. Even if teachers are not ready to fully implement student inquiry in their classrooms, they will benefit from the best practices presented in this book.

WHAT MAKES THIS BOOK UNIQUE?

Trevor MacKenzie utilizes a unique 21st Century feat to engage his readers. Throughout the text, he strategically included QR codes that lead to examples of student products from inquiry-based lessons. After scanning a QR code with a mobile device, the reader can view and interact with the graphics or videos, which demonstrate the impact of inquiry-based learning. MacKenzie includes multiple QR codes to highlight the Four Pillars of Inquiry: Explore a Passion, Aim for a Goal, Delve into Your Curiosities, and Take on a New Challenge. According to his website, "The Four Pillars are inquiry avenues that provide all learners with the support and foundation to begin to formulate their inquiry topic and their essential question." Interacting with these digital examples while reading the text makes the "impossible" of implementing yet another new teaching practice feel easy, and entirely possible.

CONCLUSION

Inquiry-based learning has become a popular method of teaching because it promotes high levels of engagement as well as affords teachers the ability to differentiate and personalize instruction for their students. Instead of fulfilling the common role of an instructor, the teacher who incorporates inquiry-based learning in their instruction acts as a learning facilitator for lessons that are driven by students (their questioning, synthesizing of information, and development of unique end-products). This book offers a wide range of teaching strategies for novice and advanced teachers alike who are interested in the inquiry approach to learning. For teachers interested in learning more about this topic, the book's final pages provide a list of ways to connect via online tools and workshops.

ABOUT THE AUTHOR

Amanda Casto is a doctoral student at the University of North Carolina at Charlotte. Her primary focus of study is elementary mathematics education and educational equity. She has ten years of experience in teaching K-8 students in a variety of educational settings including private, charter, magnet, and public schools.

Literature Review

Understanding the Influences that Contribute to African American Males Pursuing STEM Majors at Post-Secondary Institutions

Shwanda J. Williams

INTRODUCTION

As the United States battles to understand how to maintain its position as an economic powerhouse and be competitive in the global economy, the answer seems to lie with STEM education (Chen, 2009, p. 1). Although there is an increase in the number of STEM jobs and a growing popularity of the discipline, there remains a shortage of minorities in the field, particularly African American males. African American males are pursuing STEM, but at a much lower rate than their White and Asian/Pacific Islander male counterparts (U.S. Department of Education, 2010). This article provides an overview of the literature on African American males' perseverance in STEM and an examination of the reasons they are outperformed by their White male and Black female counterparts (Moore, Smith, & Madison-Colmore, 2003). The intention is to assist other practitioners and researchers who wish to address this deficit and encourage African American males to pursue STEM.

Three primary themes can be associated with African American males' persistence in STEM majors. These themes include having a strong family influence, overcoming stereotypes, and demonstrating high aptitudes in science and math (Moore, Smith, Madison-Colmore, 2003; Moore, 2006). The literature reviewed here highlights the three common influences and helps explain why they have an effect on African American male persistence in STEM. These resources also provide recommendations to practitioners and researchers regarding how to assist African American males who pursue STEM majors at the post-secondary level.

STRONG FAMILY INFLUENCE

Charleston posited (2012) that African Americans who pursued computing science degrees, a major within the STEM discipline, at the post-secondary level were found to have parents who invested in their learning during their primary years and encouraged their engagement with STEM disciplines.

Researchers have also found that verbal affirmation and active involvement are key ways that African American parents influence their sons to be persistent in STEM disciplines, and academic achievement in general. Parents also set expectations for their sons. "The more parents reinforce their expectations, the more African American males are likely to commit themselves to school—studying, learning, and making 'good' grades" (Moore, 2006, p. 262).

As parental influence seems to be a powerful recurring theme in the persistence of African American males in STEM at the post-secondary level, it is important to expand investigations around this topic. In order to do this, it will be essential for practitioners and researchers to establish and maintain meaningful relationships with the parents of African American males who are pursuing STEM at the post-secondary level (Moore, 2006, p. 262).

OVERCOMING STEREOTYPES

African American males have had to withstand negative experiences from the broader society in regard to academic achievement. These experiences tend to cement a "tempered Blackness," which allows them to focus on meaningful activities (Reid, 2013, p. 78). After undergoing an initial identity re-structure, most African American males utilize the anti-Black attitude and racial marginalization to galvanize their development (Reid, 2013). After possibly experiencing negativity or racial marginalization in STEM classrooms, those African American males can use those negative experiences to be a driving force to help them persist in STEM disciplines.

Stereotypes can often be masked by racial "micro-aggressions." According to McGee and Martin (2011) (as cited in Berry, Hughes, & Ellis, 2014) one student utilized a teacher's low expectations to serve as a motivating catalyst to success. Subtle, non-verbal implications often affect African American males in negative ways, however, some redirect the experience to make it work for their benefit. Acting in accordance with the *prove-them-wrong* syndrome, African American male participants in a research study expressed wanting to work twice as hard to overcome what professors, students, and administrators thought about their pursuit of engineering and rise to the occasion to accomplish their goals (Moore, Smith, & Madison-Colmore, 2003).

Although negative stereotypes can be hurtful, understanding that African American males sometimes use these to propel themselves to success will help researchers develop new theories and constructs as to why certain African American males persist in STEM majors at the collegiate level.

DEMONSTRATING HIGH APTITUDES IN SCIENCE AND MATH

Charleston (2012) discussed the implications of African Americans pursuing computing science degrees, stating that students who were exposed to computers at an early age began to explore advanced computing functions. Computing can serve as one form of exposure to STEM related topics. In addition to exposure, participation in advanced courses and strong preparation in high school can be a major influence on African American males pursuing STEM at the post-secondary level (Dancy, Palmer, & Maramba, 2011, p. 498). The specific groups of African American males who showcased strong aptitudes in science and math were further cultivated. Whereas, students found to be unfamiliar with STEM were less likely to perform well or pursue STEM majors (Osborne, Dewitt, & Archer, 2015, p. 220).

When students perform at a high level, it increases their level of self-efficacy. The self-efficacy theory as recorded by Maddux (1995) suggests that persistent behaviors and courses of action are likely to occur if people feel they are able to cope successfully with demands and challenges (p. 4). If African American males have a high self-efficacy due to their perception that they can perform well in STEM disciplines, this increases the likelihood of their pursuit of STEM at the post-secondary level. This theme may prove useful to educators who can further validate the self-efficacy of African American males, and encourage those students to pursue STEM due to their strong performance in the discipline.

CONCLUSION

To continue to position itself as a globally competitive country, the United States has to diversify the STEM workforce (Bidwell, 2015). African American females outperform African American males in science and mathematics in high school (St. Rose, Hill, & Corbett, 2010). In addition to their female counterparts, African American males are outperformed by their White male and Asian Pacific Islander male counterparts. This further points to the need for educators to assist African American males in their performance in STEM and encourage them in their pursuit of STEM disciplines.

The National Science Foundation (2015) reported in 2012 that only 2,356 black males were awarded engineering degrees in comparison to the 41,165 black males who were awarded non-science and engineering degrees. It is important to note that African American males are earning degrees in disciplines other than STEM. However, in order to diversify the STEM workforce and grow the education-to-workforce pipeline, more African American male STEM graduates are needed.

This literature review points to some of the reasons that African American males decide to pursue STEM. However, this research base is not definitive and further work that examines the findings presented here, as well as efforts to identify additional themes of influence, are needed.

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