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Renovating Science Professional Development to Meet Teachers' Needs

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Renovating Science Professional Development to Meet Teachers' Needs

Abstract

In order to meet the needs of elementary in-service teachers, renovated professional learning, including the components of the Effective Science Professional Development Model is vital. Increasing teachers' pedagogical content knowledge, engaging teachers in investigations, school-year coaching with the underlying theme of collaboration are encompassed in the four key components of the renovated model. Experiences shared in the article, the successes and challenges of implementing professional development with the focus of shifting science education to hands-on investigations in doing science, provide leaders in science education the opportunity to explore effective professional development opportunities and utilize this model in their schools to enhance the teaching and learning of science education.

Keywords

Science, professional development, learning communities

Renovating Science Professional Development to Meet Teachers' Needs

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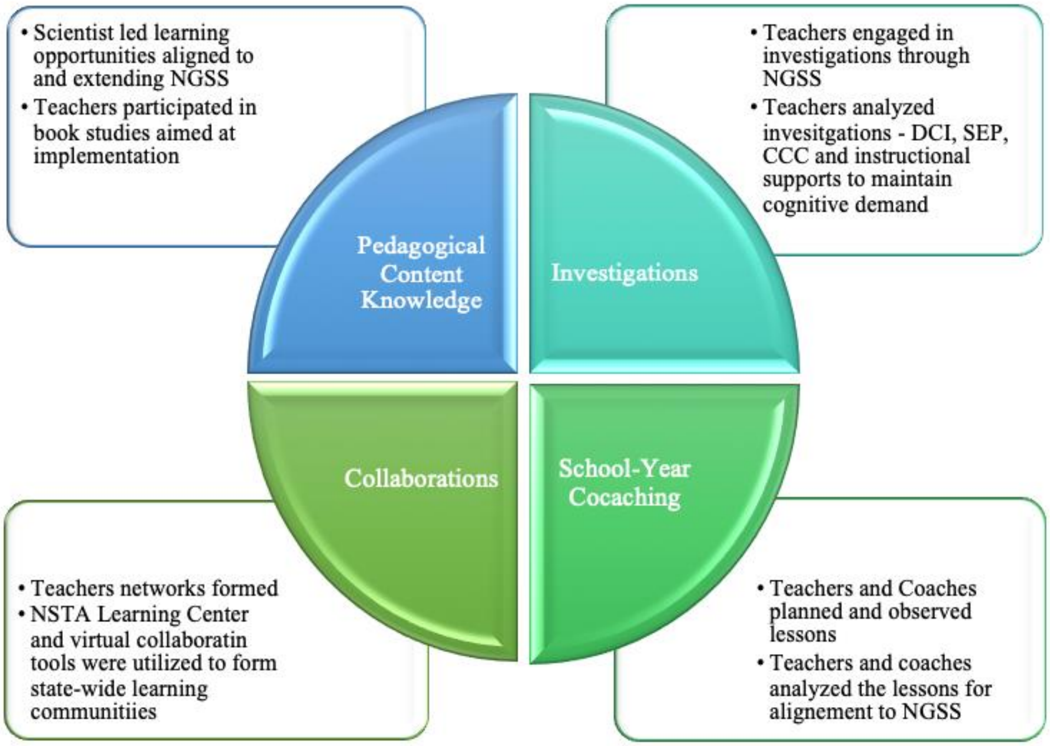
Introduction

The purpose of this reflection paper is to encourage those leading science professional development to design learning experiences for science teachers following the Effective Science Professional Development Model. This model includes creating and maintaining a collaborative learning community for teachers to engage in science investigations, with a dual purpose of increasing science content knowledge and pedagogical content knowledge, through concentrated, rigorous professional development and school-year coaching.

The need for all elementary science teachers to deeply understand the elements of the Next Generation Science Standards (NGSS) and the instructional supports that must be in place to ensure student learning for all students has never been greater. To meet this demand, we renovated professional development by designing and employing a series of coherent professional learning opportunities for K-8 science teachers from ten school districts. This is a reflection on the design and implementation of the Effective Science Professional Development Model that was used during the Kansans Can Excel grant project and a brief overview of the outcomes. The project was funded through the Kansas State Department of Education, Math and Science Partnership Grant, (USDE Award, 3KS180302). This model could serve as a road map for educators looking to design successful, sustained professional learning opportunities.

Professional development (PD) is most effective when expanded over multiple sessions, job embedded and content specific (Zepeda, 2012). Based on this general idea, university faculty and district leaders designed a series of professional learning opportunities within each component of the Effective Science Professional Development Model in Figure 1, including: opportunities during summer institutes to increase teacher knowledge of NGSS content and examination of planning, engage teachers in investigations to anticipate student thinking and school-year coaching to assist with the implementation of new ideas, all while building a learning community through strategic collaborations. This Effective Science Professional Development model was designed around the components of the (Math Science Partnership) MSP request for proposals, requiring an intensive summer institute and ongoing academic year training (KSDE, 2016). The investigations and collaborations categories of the model specify the ways in which teachers engaged in learning, which was developed from the NSTA resources listed in Table 1 and grant faculty experiences, as this was not specified in the RFP.

Figure 1. Effective Science Professional Development Model

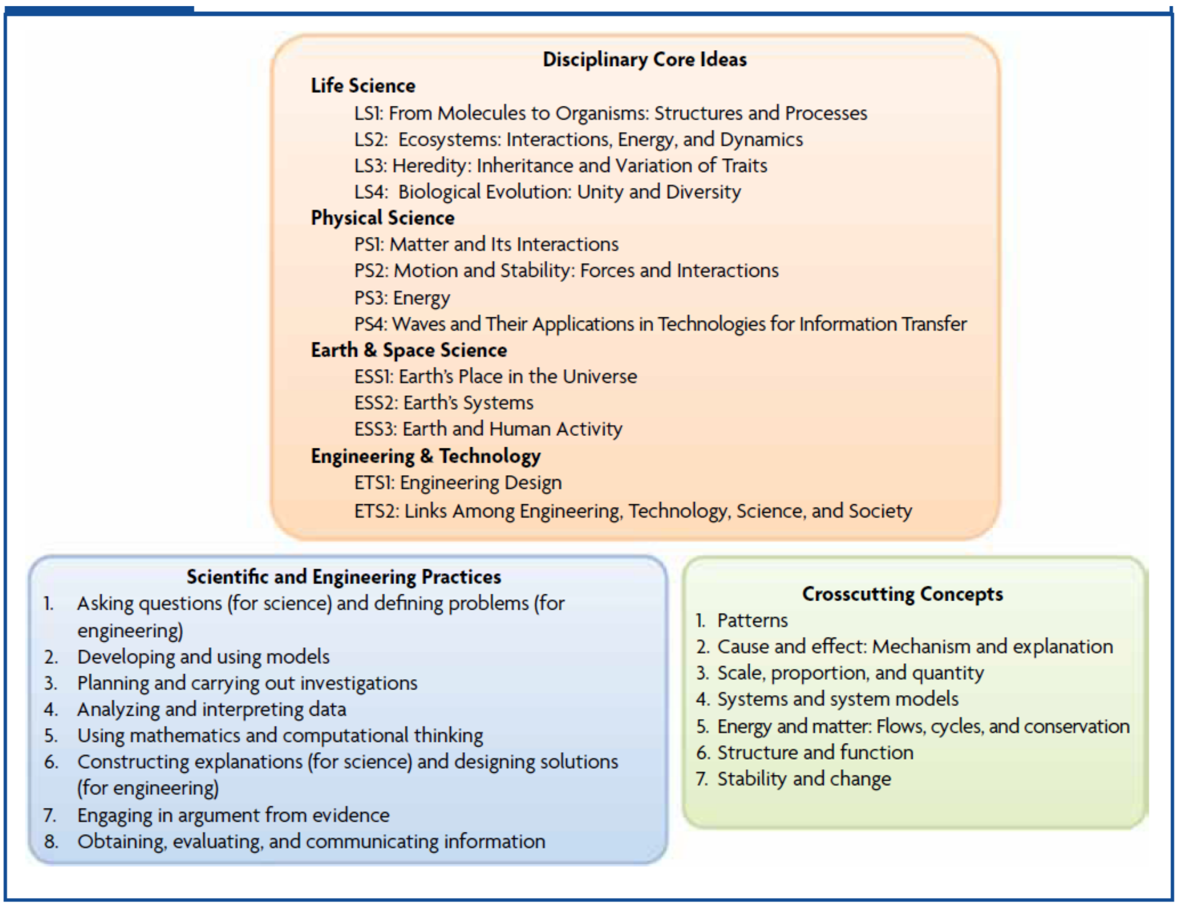


Specifically, university faculty and district leaders employed a two-week summer institute to jumpstart the professional development series aimed at improving teacher content knowledge of NGSS and implementation of effective teaching practices that support and enhance student learning. The project, funded through a Math Science Partnership (MSP) grant, allowed university faculty and staff to interact in year-round professional development, including school-year coaching followed by an additional two-week summer institute, utilizing NSTA Learning Center. Approximately forty elementary and middle school science teachers from ten school districts throughout the state participated in the science and STEM portions of the project. School-year coaching experiences were determined by individual teacher and school needs. Instructional Coaches and faculty provided professional development, job-embedded observations and instructional coaching. The 3-dimensions of NGSS were explored, (see Figure 2) with more in-depth opportunities centered on engineering components and investigations, based on results of the teachers' needs assessment. According to Karen Mesmer (2015):

> Incorporating three-dimensional learning into the curriculum involves students in doing science, using science and engineering practices and learning how certain concepts such as energy and patterns are interwoven in all science disciplines. This gives students a much more realistic picture of our world and how it works, and it allows them to see the world as a single, interconnected entity. (p.19)

Using the NGSS 3 dimensions was a new concept for most of the teachers. Through the collaborative use of technology, interaction with university content and pedagogical professors, and hands on investigations and reflection, teachers increased their science content knowledge and gained better understandings of what and how their students think, to explore supportive instructional conditions (National Research Council, 2012). Teachers lived the learning experiences their students could be engaged in during investigations to gain a deeper understanding and use of the 3-dimensions of NGSS. Utilizing resources within the NSTA Learning Center, university professors as expert scientists and University professors as expert science educators, brought depth to exploring the investigations, enhanced teachers' pedagogical knowledge needed to engage students in these high-quality learning experiences. Further details of each component of the Effective Science PD Model, with examples and implications for teachers and professional development, are expanded upon in this article.

Figure 2. The Three Dimensions of Science

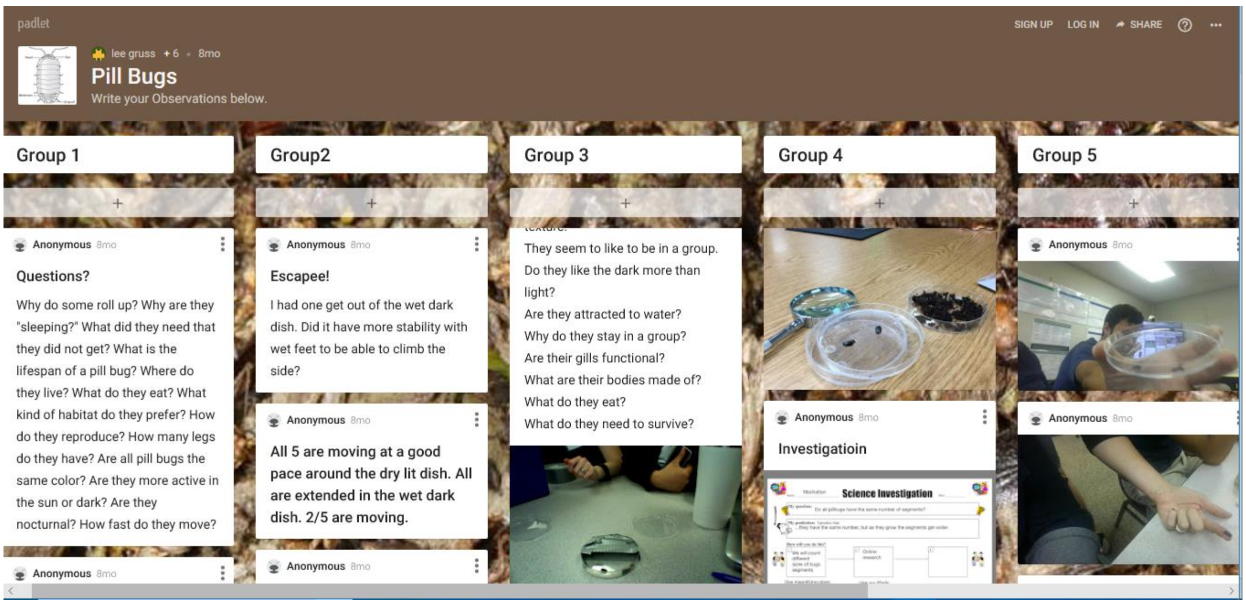


(Duncan & Cavara, 2015)

Pedagogical Content Knowledge

To demonstrate the Science and Engineering Practices (SEP) and Cross-Cutting Concepts (CCC), the first component of the Effective Science PD Model aimed to increase teachers' conceptual understandings of the science content and iteratively students' conceptual understandings (Brunsell et. al., 2014). To ensure teachers knew and understood the progression of science, prior to and beyond the grade level they were teaching, scientists from the university followed each investigation with a demonstration and discussion taking the Disciplinary Core Idea (DCI) to a deeper context (Cartier et. al, 2013). The professors attended the prior days' sessions, led by expert science educators, to observe teachers working through the investigations to gain insights into their thinking, misconceptions and how they engaged in the investigation and the SEPs. The following morning, the scientists expanded on the previous days' investigation and dug deeper into the concepts. Working collaboratively with scientists, the teachers were able to ask questions regarding the content and application of content in real-world settings. The scientists used the matrix of progressions for DCI's, SEP's, and CCC's (NSTA, 2013) to help guide their preparation and discussions with teachers. For example, in the Pill Bug investigation, scientists presented content from the investigation that teachers previously explored and provided time to ask clarification questions to increase science content understanding. Figure 3 shows teachers interacting with scientists regarding the investigation, with a focus on Life Science and SEPs.

Figure 3. Example of Teacher Padlet from Pill Bug Investigation



Teachers in the project had access to the resources listed in Table 1. These books were recommended by our science advisory board in Kansas, comprised of university professors, curriculum facilitators, district administrators and coaches, nationally engaged science teachers and project staff. These resources were used to develop investigative learning experiences and prompt discussions and teachers were provided copies of selected books to engage in a book study learning opportunity.

Table 1. Teacher Pedagogical Content Knowledge Resources

Brunsell, E. Kneser, D. & Niemi, K. (2014). Introducing Teachers & administrators to the NGSS: A professional development facilitators guide. Arlington, VA: National Science Teachers Association Press.

Bybee, R. (2015). The BSCS 5E instructional model: Creating teachable moments. Arlington, VA: National Science Teachers Association Press.
Cartier, J., Smith, M., Stein, M., Ross, D. (2013). 5 Practices for orchestrating productive task-based discussions in science. Reston, VA: National Council of Teachers of Mathematics.
Colburn, A. (2017). Learning science by doing science: 10 classic investigations reimagined to teach kids how science really works, grades 3-8. Thousand Oaks, CA: Corwin.
Moore, C. (2018). Creating scientists: Teaching and assessing science practice for the NGSS. New York, NY: Routledge.
Schwartz, C., Passmore, C., Reiser, B. (2017). Helping students make sense of the world using next generation science and engineering practices. Arlington, VA: National Science Teachers Association Press.
Vasquez, J., Sneider, C. & Comer, M. (2013). Grades 3-8 STEM lesson essentials: Integrating science, technology, engineering and mathematics. Portsmouth, NH: Heinemann.
Vasquez, J., Comer, M., & Villegas, J. (2017). STEM lesson guideposts: Creating STEM lessons for your curriculum. Portsmouth, NH: Heinemann.

Typically, a brief presentation was given on the assigned reading, which allowed common knowledge and vocabulary to be introduced and explored, as well as large group discussions and small group chats, conducted on site and virtually. Depending on the topic, teachers met in grade bands or building/district groups. This allowed our smaller districts' teachers to have peer to peer discussions with teachers facing similar content and pedagogy challenges and successes. The overarching theme centered on understanding by design, utilizing the works of McTighe (2004) to provide the common ground for understanding ways to effectively implement elements of the NGSS.

Investigations

Teachers were engaged in investigations adapted from *Learning Science by Doing Science* book to provide deep understandings of the NGSS. The different activities and subsequent discussions encouraged the practicing of behaviors needed for "doing science". By engaging in the investigations, teachers were able to anticipate student thinking, including misconceptions. Teachers worked in site-based and virtual groups to complete investigations and used note-booking to log progress and track questions that arose (The California Academy of Sciences, n.d.). The various sites were also able to collaborate and share thinking through the use of various technology platforms. For example, Padlet was used as an ongoing virtual notebook for all teacher groups to log progress through data or pictures, as well as pose questions to other groups, Figure 3 provides an example of the use of Padlet during the Pill Bug investigation. The notes collected on Padlet provided an excellent tool to facilitate a discussion on how behaviors relate to the NGSS Science and Engineering Practices and other elements of the NGSS. The focus of discussion was also structured to help teachers and subsequently their students understand what scientists do in science. The progression of science concepts was examined through the investigations, including discussions revolving around the DCI, CCC, SEP Matrix (NSTA, 2013). Throughout the institute, investigations moved from novice ideas and skill levels to a more expert level on what it means to do science, but additional support is needed to take this learning into implementation.

School-Year Coaching

A key component of the professional development model is the follow-up activities hosted by instructional coaches throughout the school year. Cobb and Jackson (2011) attest to the impact that ongoing, job-embedded training has on teacher efficacy and implementation of effective teaching strategies. This model was utilized with science teachers to promote the connectedness of the summer professional development with application during the school year. Depending on geographical location, some coaching experiences were conducted face-to-face while others utilized technology, specifically Swivl recording devices and Zoom video conferencing, to provide virtual coaching opportunities. Face-to-face and virtual coaching activities include enacting a cycle of joint planning lessons, beginning with plans generated in the summer institute, observing the implementation of lessons throughout the school year, and jointly analyzing the lessons in terms of alignment to NGSS-DCIs and the relationship to the SEPs and CCCs. Other activities included co-teaching, providing feedback, setting goals, fine-tuning practices, and working with district leadership to disseminate learning throughout the district. The resources listed in Table 2 were utilized by the instructional coaches, to frame their work with teachers.

Table 2. Coaching Resources

Brock, A., & Hundley, H. (2017). The growth mindset coach: A teacher's month-by-month handbook for empowering students to achieve. Berkeley, CA: Ulysses Press.
Knight, J. (2007). Instructional coaching: A partnership approach to improving instruction. Thousand Oaks, CA: Corwin.

The school-year coaching was essential to the collaborative efforts needed for shifting teaching strategies, effective implementation and sustained learning.

Collaborations

To further support teachers in their professional learning, DuFour & Reason (2016) emphasize the importance of site-based and virtual collaboration opportunities. Various platforms were utilized by PD leaders and teachers to form networks of teachers by school, district, content area, and grade level. In many cases, the teachers in this project, from rural and geographically isolated areas, may be the only teacher that is accountable for specific content in their building or district. This network of teachers, provided by the project, "offers intellectual, social and emotional engagement with ideas, materials, and colleagues" as substantial change and shifts are likely to take place within classroom, schools and districts if teachers are "intellectually engaged in their disciplines and work regularly with others in their field" (Zepeda, 2012, p.10). Teachers within the project joined the NSTA-Learning Center during the institute and maintained use of this valuable resource during school-year coaching and follow-up activities. During the summer institutes, Base Camp was used to share resources and provide informal opportunities for discussions. Zoom, Google Documents and Padlet were all incorporated into the investigative learning activities and books study to increase content knowledge, and as a means to work collaboratively on planning components of lesson plans to engage students in investigations.

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The resources listed below in Table 3 include the books utilized by grant staff and teachers when preparing for collaborative work time and embedded in the growth mindset initiative underlying much of the grant work.

Table 3: Teacher Collaboration Resources

Boaler, J. (2016). Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching. San Francisco, CA: Jossey-Bass.
Brock, A., & Hundley, H. (2018). In other words: Phrases for a growth mindset. Berkeley, CA: Ulysses Press.
Brock, A., & Hundley, H. (2017). The growth mindset playbook: A teacher's guide to promoting student success. Berkeley, CA: Ulysses Press.
DuFour, R. & Reason, C. (2016). Virtual collaboration: On the tipping point of transformation. Bloomington, IN: Solution Tree Press.
Kanold, T. (2011). The five disciplines of PLC leaders. Bloomington, IN: Solution Tree Press.
Ricci, M. (2017. Mindsets in the classroom: Building a growth mindset learning community. Waco, TX: Prufrock Press.

Swivl recording devices were provided for teachers to record and share examples of their teaching in action, to receive personalized coaching feedback and to help build relationships among teachers by being able to work together, even from opposite sides of the state.

Implications for Teachers

Teachers exclaimed about the success of the project and impacts to their personal and professional learning, "Other benefits from the project were the resources and connections that we were able to make use of during the investigations and book study. I learned about and feel ready to implement the 3-dimensions of NGSS in my classroom." The pedagogical practice of shifting from a lecture and content focus classroom to a hands-on, investigative focus, where students discover science by doing science, was an underlying theme of all components in the Effective Science PD Model. Implementing investigations as professional learning, allows teachers to practice what their students will be doing in the classroom, which increases their NGSS disciplinary core idea knowledge and understanding, embedding themselves in the Science and Engineering practices and examining cross-cutting concepts. Teachers should live the students' classroom experiences, analyzing their learning from the student and teacher perspective. Teachers can read about and discuss these concepts, but during these professional learning opportunities, they first need to experience the learning as a student, then critically reflected on their experiences, allowing them to anticipate challenges their students and they may encounter as they implement investigations in their classrooms. The feedback and support from instructional coaches, following these learning activities, plays an instrumental role in the long-term sustainability of improving science education. Teachers should receive tailored support and communication, based on their individual needs and goals, from coaches. Instructional coaching can often be a vulnerable process, but when coupled with the increased pedagogical content knowledge and experiences in investigations, teachers' eagerness for the ongoing support grows.

Implications for Professional Development

Professional development utilizing the four components outlined in the Effective Science PD Model allows for teachers across the state, some who are the only science teachers in their buildings, to connect with colleagues and form a support network. Many teachers reported on their individual growth and understanding of the three dimensions of NGSS. However far more expressed the benefits of the collaborative learning experience, stating, “this was an amazing learning experience. I was able to collaborate with someone, from my district or another school in the state, who was teaching the same grade and content as me” and “we were very fortunate to have the opportunity to be a virtual site for this project, which allowed our teachers the convenience of staying home while participating in this PD. We were able to have the tough conversations about aligning content across grade levels, common vocabulary, and goals that we would like to meet as a building in science.” Each component of the Effective Science PD Model is vital to the success of the professional development of teachers. Teachers must understand the content they are teaching to their students and the matrices that demonstrate the progressions of the DCI, CCC and SEPs. Teachers should examine pedagogy while learning content, not in isolation, allowing teachers to further investigate the content, from the student and teacher perspective. Establishing a collaborative learning environment, during professional development and school-year coaching opportunities, either face-to-face or virtually, provides substantially more opportunities for teachers to anticipate student thinking and the challenges they may face in the classroom, pose questions, and generate instructional supports for all students to learn science at high levels.

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DuFour, R. & Reason, C. (2016). *Professional learning communities at work and virtual collaboration: On the tipping point of transformation*. Bloomington, IN: Solution Tree Press

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