R&E-SOURCE http://journal.ph-noe.ac.at
Open Online Journal for Research and Education
Special Issue #8, September 2017, ISSN: 2313-1640

PÄDAGOGISCHE HOCHSCHULE NIEDERÖSTERREICH

Developing and Supporting Rigorous Science Education at the Elementary School Level

*Peter C. Hillman**

Abstract

This article is based on a presentation given at the International Week Conference, held at Pädagogische Hochschule Niederösterreich, Melk, in May, 2017. Rigorous science education at the elementary school level is increasingly important. In the United States, there are several historical factors that impede quality elementary science education. This paper briefly addresses the current issues in elementary science education and provides an overview of one project that is working to support the development of practicing elementary science teachers.

Keywords:
Elementary Science
Vertically Alignment
Professional Learning Communities
Professional Development

1 Introduction

In the United States, there is a national concern about the quality of elementary science teaching (Olson et al., 2015). Elementary school teacher preparation has traditionally followed a generalist approach (Keir, 2017; Appleton & Kindt, 1999). Many elementary teachers lack adequate preparation or academic backgrounds for teaching science (Lee et al., 2008; Tosun, 2000; Tilgner, 1990) which in turn leads to a lack of confidence and desire to teach science at the elementary level (Appleton, 2013; Avraamidou, 2013; Abell & Roth, 1992). In part, these concerns are the result of national policy decisions, such as the No Child Left Behind Policy (2001), which requires all students in grades 3–8 to be strictly assessed on language arts and mathematics annually. In order to accommodate these requirements, local school districts have turned their major educational focus to the English language arts and Math (Blank, 2012; Buczynski & Hansen, 2010), which has resulted in science, art, physical education and other subjects being given low priority or dropped completely.

One way to gauge the impact of such policies is to examine the 2012 National Survey of Science and Mathematics Education by Banilower et al., (2013). This survey was designed to provide information and to identify trends in the areas of teacher background and experience, curriculum and instruction, and the availability and use of instructional resources. A total of 7,752 science and mathematics teachers in schools across the United States participated in this survey, a response rate of 77 percent. Looking at this survey we see that science instruction does not occur every week in 41% of K-3 classrooms and 32% of 4-6 classrooms. Additionally, the average number of minutes per day teaching science is 19 in grades K-3 and 24 in grades 4-6. By comparison, Mathematics is taught every day in both K-3 and 4-6 with an average of 54 minutes (K-3) and 61 minutes (4-6) and English language arts average 89 and 91 minutes a day (K-3 and 4-6 respectively). Using these data it is clear to see that science has become undervalued as a subject in elementary school.

The concerns with science education at the elementary level are particularly problematic today in the United States as many states are in the process of adapting a new set of science standards named the Next Generation Science Standards (NGSS). With the shift to NGSS or NGSS aligned standards, there is a critical need for high quality science instruction in elementary schools. This study examines the experience of elementary teachers engaged in a two year professional development fellowship. The fellowship is designed to support them as they

* School of Education, Mercy College, 555 Broadway, Dobbs Ferry, NY 10522, USA.
Corresponding author. E-mail: phillman@mercy.edu

participate in professional learning communities aligned to reflect the new standards and comprised of other science teachers from both middle and high school settings.

2 Overview of the Research Project

This study took place in the context of a large, privately-funded program designed to support the development of science teacher leaders. The program is a partnership between three university sites in the Northeast United States to provide professional development to strengthen the practice and leadership skills of K-12 science teachers while allowing them to stay in the classroom. The larger project aims to understand the ways in which the fellowship program supports science teachers as they develop in the following areas: science-teacher beliefs; the ways adult learn; and teacher leadership. The program is also interested in how science teacher leaders build capacity in their schools and districts. Improving science, technology, engineering and mathematics (STEM) education in K-12 classrooms will require excellent STEM teachers (President's Council of Advisors on Science and Technology, 2010). In light of the new NGSS (NGSS lead states, 2013), it is particularly important that new teachers receive explicit instruction in incorporating STEM pedagogical strategies, e.g., engineering design, into their classrooms (Cheng & Gilbert, 2014).

3 Theoretical Grounding

The NGSS standards call for substantial modifications to the content and form of teacher instruction (Polikoff, 2014). As a consequence, professional development (PD) for all teachers will need to become significantly more aligned to NGSS if there is to be useful PD for currently practicing teachers. According to Wilson, (2013), *"the U.S. PD system is a carnival of options"* (Wilson, 2013). Reiser, (2013), suggests that professional development for science teachers must become far more consistent and address areas in meaningful focused ways. Effective PD must also focus on the vertical nature of the new standards. Effective PD must be deeply embedded in subject matter (Luft & Hewson, 2014; Banilower et al., 2007; Garet et al., 2001; Cohen, 1990), designed to involve active learning (Wilson, 2013; Banilower et al., 2007; Mundry & Loucks-Horsley, 1999), able to connect teachers to their own practice (Heller et al., 2012; Fullan, 2007; Loucks-Horsley & Mastumoto, 1999) and part of a coherent system of support (Whitworth & Chiu, 2015; Reiser, 2013; Birman et al., 2000).

In an educational context, professional learning communities (PLCs) emerged in the latter half of the 1980s, originally being termed *"learning communities"* (Hord, 1997). The concept of the learning community originates from the business domain, where there was an increasing need within organizations to share, develop and nurture professional knowledge, also known as human capital, in an attempt to promote the building of knowledge, leadership and innovation from within organizations. Learning communities are defined as a group of people that act on an ongoing basis to develop their knowledge of a common interest or passion, by sharing individual resources and by engaging in critical dialogue (Wenger, McDermott, & Snyder, 2002). While PLCs do not differ greatly from learning communities, the educational context has been relatively well studied and as such, there is broad consensus for the definition. Hord's commonly used definition describes PLCs as a community of *"Five Dimensions"*. These are 1) supportive, shared leadership, 2) collaborative learning with a student needs focus, 3) shared vision and values focused on student learning, 4) supportive structural and interpersonal conditions, and 5) shared practice (Hord, 1997; Hord & Sommers, 2008).

The concept of PLCs in schools is far from new. In the last several decades there has been much advancement in the knowledge of the skills and content that are needed to achieve educational reform (Hord, 1997). While PLCs are enthusiastically acknowledged as important for encouraging and supporting professional growth amongst teachers, there is a lack of knowledge in the literature about how PLCs are developed and sustained (Dooner, Mandzuk, & Clifton, 2008). A focus on the vertical and horizontal articulation of science content as called for in NGSS may be one way to help teachers see the connections between the science content the teacher covers in their curriculum and the science a student is exposed to over the course of their school career. Multiple examinations of PLCs in the literature have identified that when teachers are engaged in learning communities there are many benefits. These include, amongst other things, higher commitment levels and improved effectiveness, the creation and sharing of a large body of professional knowledge, a shift in school culture towards shared decision making, and a positive impact on longevity of teachers' careers (Darling-Hammond, 1996; Hord, 1997; McLaughlin & Talbert, 2006; Rosenholtz, 1989). However, lacking in the literature is knowledge about how science teachers can effectively interact and collaborate with fellow science teachers through the inquiry-based design that PLCs are built around (Dooner et al., 2008; McLaughlin & Talbert, 2006). Finding ways to best support science teachers' growth and practice is a priority and requires more research in varied methods to meet the demands of our changing world for educated future citizens (Fulton, Doerr, & Britton, 2010).

4 Methods

This qualitative study is grounded in a theoretical framework of social constructivism (Berger & Luckmann, 1966), in which learning is constructed as a group through interaction and collaborative knowledge building (Creswell, 2013). The subjects are 60 science teachers (K-12) enrolled in a two-year science education fellowship. Specifically, this work focuses on the experience of the fellows who are elementary science teachers. Improved science teacher awareness of the vertical progression of scientific knowledge and horizontal relatedness expected in NGSS, would allow for the increased understanding of the level of knowledge and understanding a student is expected to meet during each step of their academic career. In the course of a two-year fellowship the participants (fellows) work in vertically aligned PLCs (V-PLCs) and use video recordings to observe one another's classroom practice and use a research topic and specific content area as a platform to share knowledge, feedback, and support.

4.1 Research Question

Amongst practicing elementary science teachers, to what extent and how do vertically aligned professional learning communities (V-PLCs) provide opportunities for professional growth, support and development?

4.2 Data Collection

This study examines data collected from fellows in five diverse, high-needs districts near a large metropolitan area. The teacher fellows had varying levels of experience with a range of science content area expertise and grade levels (K-12). This study examines the V-PLC phase of the first year. During this phase, fellows received regular PD contact with a university based leadership team and also met regularly to debrief with their V-PLC team. The data sources analyzed are summarized in Figure 1 below:

Professional Development (Leadership Team Directed)		**Fellows Independent and Group Work**	
Activities	*Data Sources*	*Activities*	*Data Sources*
• Monthly Meetings • End of PLC presentations • Annual tri-site conference	• Fellow communications • Researcher notes • Presentations from fellows	• V-PLC debrief meetings • V-PLC lesson videos • Monthly reflections	• Videos • Meeting notes • Written reflections

Figure 1: Overview of data sources, the activity which provided the data source and who directed the activity.

5 Findings

Once collected, repeated passes of the data were conducted and open and axial coding (Strauss & Corbin, 1990; Charmaz, 2006) analysis techniques were used to identify emerging themes. The research project is ongoing and as such, data analysis also continues. However, thus far, two major themes have emerged through the data analysis process and these are briefly presented below.

5.1 Theme 1: The Use of Scientific Language

Science content language was often referenced during debrief meetings. Melinda, an elementary school teacher, acknowledged how Dwight, a high school chemistry and biology teacher, had used scientific language to connect two related concepts, closed systems and gas laws. Melinda identified how Dwight modeled correct scientific language for students, essentially defining what would be acceptable scientific language and/or vocabulary to use when describing or explaining closed systems and gas laws.

"What I really appreciated was, how you integrated even the terminology of closed systems. You connected that concept to a concept on the behavior or gasses. 'Cause as soon as you said closed systems, I was thinking of energy and how to integrate that into that, and they actually understood it. I thought that was very impressive. Because just from this, from that point, you set the stage for them to use their academic language, vocabulary, throughout their explanations." (Melinda's feedback provided to Dwight in video recorded V-CCLS debrief).

Findings also showed that during V-PLCs, fellows gained insight into incorporating scientific language for common core skill development. Examples of this appreciation are shown below:

"As an elementary school teacher I am challenged to show how science can support students in reaching the Common Core Standards. There is a meaningful connection between those subjects and science. Science promotes authentic language use, particularly for ELLs."

"It is important for teachers to build common language and understand what students are learning and will be learning in the future. Seeing the connection and deepening understanding help teachers understand their part in the continuum."

5.2 Theme 2: Self and Peer Guided Professional Growth

Fellows identified various aspects of the V-PLC process that created a 'culture of mutual respect'. This allows fellows to grow and learn in an environment that provided support, respect and shared practice. Some quotes from fellows demonstrating this are shown below:

Charlie (Post V-PLC Reflection) *"We had a mutual respect for one another and the challenges each one of us faced when teaching our specific grade level."*

Maria (Post V-PLC Reflection) *"I think that the fellowship has done a wonderful job of establishing a culture where we all felt competent and comfortable to be honest about our opinions and comments."*

Fellows were also able to identify the importance of vertical collaboration with colleagues and the importance of developing a professional identity through this collaboration. For example:

"Collaboration must involve a willingness to be an active participant in an external growth process involving ongoing critical reflection on classroom practices. The process requires infusing personal beliefs and values into ones shared and individual professional identity."

Across data sources, fellows stressed the importance of working with other teachers at diverse grade levels and reflecting with them to improve their practice and learn new strategies. Comments in journal reflections included, *"Working in vertical learning teams made me consider how instruction was delivered before and how it will be delivered once students leave me."*

"Teachers at the elementary level often feel like we are teaching in a bubble because our schedules do not allow time for us to see our colleagues teaching and have time to debrief on the success of a lesson. This opportunity has allowed me to incorporate new ideas, strategies, and knowledge into my teaching practices."

6 Implications

It is clear from the data that V-PLCs provided many areas that supported growth and development for elementary teachers. Elementary teacher fellows both provided other fellows and received feedback on a multitude of pedagogical and content related areas. The fellows also identified the importance of collaboration amongst the K-12 science teacher fellows. A key theme found throughout the data was the importance of language in the science classroom. This finding is supported by several recent publications examining the requirements for NGSS implementation and success including that of Lee, Quinn, and Valdés (2013), who identify that*; "An important role of the science teacher is to encourage and support language use and development in the service of making sense of science."* Indeed, the fellows' feedback and reflection falls very much within this understanding of the central role of language in the science classroom. Fellows learned new modalities to facilitate this. For example, using technology to aid in language use and development, and stressing to students the necessity of using scientific language in descriptions of concepts in the appropriate context. All of these aspects that were shared and learned amongst the fellows fall under the second of Hord's five dimensions of PLCs (collaborative learning with a student needs focus). In addition, elementary teachers found themselves validated in their language use and saw how student scientific language would need to progress through the school experience.

The model of V-PLCs provides an effective community for teachers of all grade levels and content areas to develop an appreciation and understanding of the way that science will be taught from here forward. While the data analysis is still on going, it is clear that V-PLCs provide an important structure for all science teachers to grow and develop within. Specifically, elementary science teachers are able to use V-PLCs to develop their own practices, learn content, understand how important their position in the science education continuum is, and develop mutual respect and trust amongst their peers. Building knowledge of practice is a widely recognized mode of teacher learning. As described by Cochran-Smith and Lytle (1999); *"the basis of knowledge of practice is that teachers across the professional life span play a central and critical role in generating knowledge of practice by making their classrooms and schools sites for inquiry, connecting their work in schools to larger issues, and taking a critical perspective on the theory and research of others."* The V-PLC model provides fellows access to knowledge of shared practice and content across the K-12 spectrum. In essence, this is Hord's fifth dimension of PLCs (shared practice), with the additional benefit of building professional capital in teams and the fellowship as a whole.

Examination of the fellowship data is ongoing and more publication in the area is anticipated.

References

Achieve, Inc. (2013). *Appendix H - The Nature of Science in the Next Generation Science Standards.*

Abell, S. K., Appleton, K., & Hanuscin, D. L. (Eds.). (2013). *Handbook of research on science education*. Routledge.

Abell, S. K. & Roth, M. (1992). Constraints to teaching elementary science: A case study of a science enthusiast student teacher. *Science Education*, *76*(6), 581-595.

Appleton, K. & Kindt, I. (1999). Why teach primary science? Influences on beginning teachers' practices. *International Journal of Science Education*, *21*(2), 155-168.

Avraamidou, L. (2013). Prospective elementary teachers' science teaching orientations and experiences that impacted their development. *International Journal of Science Education*, *35*(10), 1698-1724.

Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). *Report of the 2012 National Survey of Science and Mathematics Education.* Horizon Research, Inc.

Banilower, E. R., Heck, D. J., & Weiss, I. R. (2007). Can professional development make the vision of the standards a reality? The impact of the national science foundation's local systemic change through teacher enhancement initiative. *Journal of research in science teaching*, 44(3), 375-395.

Berger, P. L. & Luckmann, T. (1966). *The social construction of reality.* New York.

Birman, B. F., Desimone, L., Porter, A. C., & Garet, M. S. (2000). Designing professional development that works. *Educational leadership*, 57(8), 28-33.

Blank, R. K. (2012). *What is the impact of decline in science instructional time in elementary school.* Noyce Foundation. Available at: http:/www.csss-science.org/downloads/NAEPElemScienceData.pdf

Buczynski, S., & Hansen, C. B. (2010). Impact of professional development on teacher practice: Uncovering connections. *Teaching and Teacher Education*, 26(3), 599-607.

Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative research.* SagePublications Ltd, London.

Cochran-Smith, M. & Lytle, S. L. (1999). Chapter 8: Relationships of knowledge and practice: Teacher learning in communities. *Review of research in education*, 24(1), 249-305.

Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches*. SagePublications.

Creswell, J. W. (2007). *Qualitative Inquiry and Research Design: Choosing among five approaches* (2nd ed.). Thousand Oaks, CA: Sage.

Darling-Hammond, L. (1996). The Quiet Revolution: Rethinking Teacher Development. *Educational leadership,* 53(6), 4-10.

Dooner, A.-M., Mandzuk, D., & Clifton, R. A. (2008). Stages of collaboration and the realities of professional learning communities. *Teaching and Teacher Education,* 24(3), 564-574.

Fullan, M. (2007). Change the terms for teacher learning. *Journal of staff development*, 28(3), 35-36.

Fulton, F., Doerr, H., & Britton, T. (2010). *STEM teachers in professional learning communities: A knowledge synthesis.* National Commission on Teaching and America's Future.

Heller, J. I., Daehler, K. R., Wong, N., Shinohara, M., & Miratrix, L. W. (2012). Differential effects of three professional development models on teacher knowledge and student achievement in elementary science. *Journal of Research in Science Teaching*, 49(3), 333-362.

Hord, S. M. (1997). *Professional learning communities: Communities of continuous inquiry and improvement.*

Hord, S. M. & Sommers, W. A. (2008). *Leading professional learning communities: Voices from research and practice*. Corwin Press.

Kier, M. W. & Lee, T. D. (2017). Exploring the role of identity in elementary preservice teachers who plan to specialize in science teaching. *Teaching and Teacher Education,* 61, 199-210.

Lee, O., Maerten-Rivera, J., Penfield, R. D., LeRoy, K., & Secada, W. G. (2008). Science achievement of English language learners in urban elementary schools: Results of a first-year professional development intervention. *Journal of Research in Science Teaching*, 45(1), 31-52.

Lee, O., Quinn, H., & Valdés, G. (2013). Science and language for English language learners in relation to Next Generation Science Standards and with implications for Common Core State Standards for English language arts and mathematics. *Educational Researcher*, 42(4), 223-233.

Loucks-Horsley, S., & Matsumoto, C. (1999). Research on professional development for teachers of mathematics and science: The state of the scene. *School science and mathematics*, 99(5), 258-271.

Luft, J. A., & Hewson, P. W. (2014). Research on teacher professional development programs in science. *Handbook of research in science education*, 2, 889-909.

McLaughlin, M. W., & Talbert, J. E. (2006). *Building school-based teacher learning communities: Professional strategies to improve student achievement* (Vol. 45): Teachers College Press.

Mundry, S., & Loucks-Horsley, S. (1999). Designing Professional Development for Science and Mathematics Teachers: Decision Points and Dilemmas. *NISE Brief*, 3(1), n1.

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

Olson, C. B., Scarcella, R., & Matuchniak, T. (2015). English learners, writing, and the Common Core. *The Elementary School Journal,* 115(4), 570-592.

Reiser, B. J. (2013). *What professional development strategies are needed for successful implementation of the Next Generation Science Standards.* Paper presented at the Invitational Research Symposium on Science Assessment. K-12 Center at ETS, Wahington, DC.

Rosenholtz, S. J. (1989). *Teachers' workplace: The social organization of schools*: Addison-Wesley Longman Ltd.

Corbin, J. & Strauss, A. (1990). Grounded theory research: Procedures, canons and evaluative criteria. *Zeitschrift für Soziologie*, 19(6), 418-427.

Tosun, T. (2000). The beliefs of preservice elementary teachers toward science and science teaching. *School science and mathematics*, 100(7), 374-379.

Tilgner, P. J. (1990). Avoiding science in the elementary school. *Science Education*, 74(4), 421-431.

Wenger, E., McDermott, R. A., & Snyder, W. (2002). *Cultivating communities of practice: A guide to managing knowledge*. Harvard Business Press.

Whitworth, B. A., & Chiu, J. L. (2015). Professional development and teacher change: The missing leadership link. *Journal of Science Teacher Education*, 26(2), 121-137.

Wilson, S. M. (2013). Professional development for science teachers. *Science,* 340*,* 310-313.