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Vertically Articulated Professional Learning Communities

Building Collaboration and Practice amongst K-12 Science Teachers

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Abstract

This article is based on a presentation given at the International Week Conference, held at Pädagogische Hochschule Niederösterreich, Baden, on June 1st, 2016. In the United States, the Next Generation Science Standards (NGSS) represent a major shift in the way that science is taught and learned in schools. One major part of this shift is the emphasis on a progression of scientific knowledge from K-12. We examine professional learning communities that are orientated to align with the vertical progressions of scientific knowledge emphasized in NGSS. Using qualitative methodology embedded in a constructivist theoretical framework, we describe our use of vertically aligned groups of science teachers constructed around a particular content area (earth science, biology, chemistry or physics). We present an overview of several emergent themes that we have identified from our data analysis.

Keywords:
Professional Learning Communities
K-12 Science Teachers
Improving Practice
In-Service Support and Guidance

1 Introduction

In the United States, the implementation of NGSS in science classrooms requires a significant shift in the way that science teachers teach. In particular, teachers need to be familiar with the vertical articulation of the standards laid out in the NGSS. These standards allow for the identification of the level of understanding a student is expected to meet during each step of their academic career. These learning progressions allow educators to not only target students' learning for the grade they are currently teaching, but also provide guidance on the level of understanding for a concept that the student should be arriving with from the previous grade and what they will be expected to build to for the next grade level (Duncan & Rivet, 2013). Despite the focus on standards based reform in the United States, many teachers are still left in the dark with little guidance when it comes to what to teach or how to teach it (Kauffman, Johnson, Kardos, Liu, & Peske, 2002). Academic debate has shifted from if standards should be used to guide professional development, to how they should be used most effectively (Loucks-Horsley, Love, Stiles, & Mundry, 2010). According to Wilson (2013), there is not one straightforward approach to supporting teachers in implementing NGSS due to the complexity of the education system in the United States. Thinking about content throughout a students' vertical development is a somewhat untapped opportunity for teacher professional development.

In the United States, Teachers' understanding of science content and efficacy for teaching science varies by grade. In many cases, secondary science teachers are required to take more coursework in science content knowledge than elementary school teachers who teach science in addition to other content areas. Past research indicates that elementary teachers who lack understanding of science content also self-identify as having low levels of confidence for teaching science and often avoid teaching it (Epstein & Miller, 2011; Harlen

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& Holroyd, 1997; Harlen & James, 1997). A focus on the vertical articulation of science content, as called for in NGSS, may be one way to help teachers see the connections between the science content he or she teaches that year and the science content a student is exposed to over the course of their school career. In an attempt to help teachers make these connections, this case study sought to investigate the following research question: How do vertically articulated Professional Learning Communities (PLCs) support science teaching practices in the context of NGSS?

2 Study Setting

Our 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 Framework

This research is grounded in a theoretical framework of social constructivism, in which learning is constructed as a group through interaction and collaborative knowledge building. In social constructivism, *"... the process of constructing meaning always is embedded in a particular social setting of which the individual is a part"* (Duit & Treagust, 1998, p. 8). The teachers in our study built understandings of teacher leadership and vertical articulation as it relates to their classroom through interactions with colleagues on their team. Using this framework for teacher professional learning, teachers work together as a team and then internalize their individual ideas (Richardson, 1997). As Palinscar (2005) describes, *"learning and understanding are regarded as inherently social; and cultural activities and tools (ranging from symbol systems to artifacts to language) are regarded as integral to conceptual development"* (p. 348). The teacher fellows in our program are constantly reflecting on their experiences, both individually and collaboratively—asking new questions and generating shared beliefs and understandings.

4 Literature

In an educational context, professional learning communities (PLCs) emerged in the latter half of the 1980s, and were originally 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 groups 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).

In the last several decades there has been much advancement in the knowledge of the skills and content knowledge needed to improve teaching and support educational reform (Hord, 1997; Vanblaere & Devos, 2016). 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; Jones, Gardner, Robertson, & Robert, 2013; Tichnor-Wagner, Harrison, & Cohen-Vogel, 2016). We believe a focus on the vertical 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. Our work examines collaboration among practicing science teachers working in vertical (K-12) teams or professional learning communities.

5 Methodology

This research is a qualitative case study of teacher fellows. Crotty (1998) notes that the case study methodology is well-aligned with the constructivist theoretical framework. Case studies result in a rich description of themes emerging from the data sources and seek to bring together research participants into a *"bounded system"* for the sake of better understanding their experiences and perspectives (Merriam, 1998). In this case, the bounded system included the science teacher fellows participating in our program. Utilizing qualitative methodologies allowed us to explore the participants' views in their own words and better understand how their participation in the community influences their ideas about teaching and learning. This study examines data collected from 20 teacher fellows from five diverse, high-needs districts in the vicinity of a large metropolitan area. The teacher fellows had varying levels of experience with varied range in science expertise, science content area expertise and grade level (K-12). During the first year of the fellowship, teachers participated in monthly professional development sessions and extensive group work with one another to analyze their own teaching and that of their colleagues in the program. Teacher fellows took turns showing video of their teaching in their classrooms and followed an extensive protocol (Collaborative Coaching and Learning in Science Model) (Chen, Scheff, Fields, Pelletier, & Faux, 2014) for group and individual reflection. During the first semester of the program, fellows were organized into V-CCLS teams (Vertical Collaborative Coaching and Learning in Science teams) of five teachers. The vertically aligned groups were constructed around a content area (earth science, biology, chemistry or physics) and included at least one fellow from each grade level grouping (K-5, 6-8, and 9-12).

Using varied data sources, including: fellow reflections; videos of fellows teaching; fellow feedback to other fellows; fellow notes of group meetings; and field notes from professional development sessions, our research team examined the perspectives of teachers working in V-CCLS teams as they relate to professional practice. The data, collected as described above, were analyzed using the techniques of grounded theory analysis (Charmaz, 2000; Dey, 1993). We went through each piece of the data, made notes about ideas that arose, getting a feel for all of the data as a whole first, or a *"general sense"* of the data (Creswell, 2003, p. 191). We then highlighted common ideas and used constant comparison among data sources, before using multiple passes to chunk ideas and describe categories, finally collapsing categories into themes. These techniques are based on the processes of open and axial coding (Charmaz, 2000; Glaser & Strauss, 1967; Strauss & Corbin, 1990).

6 Findings

Upon examination of the data, two themes emerged that revealed valuable insight into benefits associated with V-CCLS.

6.1 Theme 1 - Trust and Constructive Peer-Peer Feedback

During the V-CCLS phase, fellows met independently in their team on at least five occasions. Each meeting was focused on debriefing one of the team member's video recorded lessons. Fellows reported that the debrief meetings provided many benefits to them, both in the receipt of feedback on their teaching and the presenting of feedback to their peers about their teaching. Building trust in their peers was one specific area that fellows identified as important during this phase. This is evidenced below in a written fellow reflection that describes the increasing trust between fellows as they meet over the period of one semester. Each meeting increased their trust and respect for each other's experiences and perspectives as science teachers:

"As we meet more and more, we trust each other more and more and we can really be frank and say what we feel needs saying. I feel that we are able to really talk about teaching from our own perspective, and learn from the perspective of others." (debrief meeting reflection)

This building of trust and respect between V-CCLS team members permitted the fellows to challenge themselves to try new approaches in their classroom. For example, the following exchange occurs between Linda, a ninth grade biology teacher, and her team after she had taught an inquiry lesson in her classroom for the first time and recorded it for the team to debrief on. It is important to appreciate that this V-CCLS had chosen to focus on inquiry in their practice and for Linda this was an entirely new and somewhat intimidating instructional approach. The lesson shown to her peers was an attempt to turn a very traditional and prescribed lab into an inquiry lesson. One of her team members identified and described it in the debrief, as shown below:

"This is something you have to do, is set up by the state in a certain way. And I think you modified it to work with not just front-loading information. You modified it so that the kids could do it on their own and think through it."

Relinquishing control of the lesson to her students was clearly a struggle for both Linda and her students. Yet Linda trusted that her V-CCLS team members would provide her with support and feedback that would help her grow in this "new to her" style of instruction. It is noteworthy that Linda identifies that she could have shown them a better lesson at a later stage, yet that she was confident enough to share the attempt with them. Linda: *"You know, if it didn't work, I could have said, 'Oh, my lesson kind of flopped.' We have to do mine later, you know."* Instead, Linda felt confident enough to show her peers what she had taught and listen to their feedback to improve her own practice.

This exchange illustrates that a benefit of the video observation component in the fellowship was the building of trust and respect amongst the fellows and their peers. However, even more so, video observations and subsequent feedback received during the debriefing sessions provided fellows with a multitude of peer feedback, support and insight upon which to draw, which, in turn, provided fellows with motivation to share more within their teams. Evidence of this was seen in many examples of fellow-fellow interactions during video debrief meetings and in subsequent post-debrief written reflection journals that indicated fellow learning occurring centered on student success in their classrooms: One fellow, explains this broadly in the following statement on her recorded debrief video:

"I do recognize that, you know, there are bits and pieces in everybody's lesson that would help to make my science teaching stronger." (V-CCLS video debrief)

Here, our fellow refers to "stronger teaching", which shows that she felt that the peer-peer interactions, observations, debriefs, etc. provided opportunities to develop her teaching.

6.2 Theme 2 – K-12 Scientific Language

Our fellows provided constructive feedback and shared common understandings about content-specific language and teacher language in the science classroom. Additionally, fellows also shared their own experiences using science language in the classroom, and discussed new methods/models/ideas for teaching and holding students accountable for scientific language.

6.2.1 Teacher Language

Teacher language was commonly referenced during debrief meetings. For example, Melinda, an elementary school teacher acknowledged how Dwight, a high school chemistry and biology teacher, had used scientific language to describe and connect two related concepts, closed systems and gas laws. As such, modeling for students by using correct scientific language and 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, uh, the terminology of closed systems. You connected that concept to a concept on the behavior or gases. 'Cause as soon as you said close systems, I was thinking

more of energy and how to integrated that into that, and that 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)

6.2.2 Content Specific Language

Many fellows identified the value of video based feedback for analysis of their own practice. For example, Andrea used the video recording to observe aspects of her class that she had not been able to see at the time of teaching. Andrea was particularly interested to see the engagement level of her students and their use of accountable talk with content specific vocabulary. During the group debrief of Andrea's lesson, her V-CCLS team noted their appreciation for the use of technology in her teaching and also identified that she was utilizing different modalities to incorporate scientific language in her classroom. Victor, a high school chemistry teacher, wrote the following in his debrief notes on Andrea's lesson:

"Science is a 'new' language and there needs to be a big emphasis on language instruction by using different modalities. Tech can be one of these modalities." (Victor written debrief notes)

The importance of teacher language use emerged from the teachers' work together and is a notable theme. Fellows identified and shared the importance of a common scientific language as it pertains to the progression of scientific knowledge that a student builds in their school career. This speaks directly to the reasoning behind V-CCLS; In this case, scientific language. Such vertical understanding is evidenced in the reflection below:

"It's 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 helps teachers understand their part in the continuum." (Fellow reflection)

Other fellows' reflections or feedback also supported the importance of using scientific vocabulary appropriately in science teaching, for example, describing what students will be expected to do during a lesson. Marie, a middle school teacher observed that during his lesson, Henry, an elementary school teacher, focused his students on their role in the classroom, by simply labeling the roles of the students and using scientific vocabulary to describe the activities they would complete.

"it changed the nature of the lesson just to begin using the words engineers, design, um, um, yeah, engineers and design and how uh, making the analogy that that's what engineers have to do, they have to figure out what an electrician has to do."

Discussion and constructive feedback between fellows was also observed centered on using content vocabulary in context. Specifically, fellows discussed the importance of appropriate scientific language for student success and additionally, that this language needs to be used in the correct context. The evidence of fellows talking about the importance of language across multiple data sources, including the video recordings, written reflections, and debrief notes emphatically illustrates the importance of this theme.

7 Discussion

In this study we examined vertically aligned professional learning communities in the context of a two year teaching fellowship. Specifically we were interested in how vertically aligned PLCs helped science teachers to grow in their understanding and support of student learning. Findings suggest that mutual trust and respect is a critical component necessary for the effective peer-peer interactions. Trust and respect as critical components of science teacher PLCs have been reported previously in the literature (Fulton, Doerr, & Britton, 2010; Richmond & Manokore, 2011), however, it is especially important to acknowledge that this finding is unique in that it incorporates K-12 science teachers, across five different school districts, working in vertically aligned teams.

In our second theme, we identify the collaborative appreciation amongst our K-12 science teacher fellows for 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, our fellow's 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, such as the use of 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 our fellows fall under the second of Hord's five dimensions of PLCs (collaborative learning with a student needs focus).

The value of the vertical nature of the PLCs in this study was noted by researchers through discussions with fellows and fellowship meeting activities. Frequently, fellows expressed their satisfaction with the peer-peer nature of the CCLS group work (field notes). More specifically, fellows often discuss the positive impact of the trust and respect that is felt amongst the members of these groups. Such positive interactions have other benefits too, such as the sharing of feedback aimed at helping improve student success in the science classroom. The bond formed between fellows is evident to the research team in the 'sadness' expressed by fellows when they have to form new groups – they seem to truly bond and befriend one another.

One fundamental goal of our fellowship is building knowledge of practice, which 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."* Our V-CCLS model provides fellows access to knowledge of shared practice and content across the K-12 spectrum. In essence, they are participating in Hord's fifth dimension of PLCs (shared practice), with the additional benefit of building professional capital in teams and the fellowship as a whole.

References

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

Chen, R. F., Scheff, A., Fields, E., Pelletier, P. & Faux, R. (2014). *Mapping Energy in the Boston Public Schools Curriculum. Teaching and Learning of Energy in K–12 Education.* Springer.

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

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

Crotty, M. (1998). *The foundations of social research: Meaning and perspective in the research process.* Sage.

Dey, I. (2003). *Qualitative data analysis: A user friendly guide for social* scientists. Routledge.

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

Duit, R. & Treagust, D. F. (1998). 1.1 Learning in Science-From Behaviourism Towards Social Constructivism and Beyond. B. J. Fraser & K. G. Tobin (Eds.), *International handbook of science education,* 3-25.

Duncan, R. G. & Rivet, A. E. (2013). Science learning progressions. *Science,* 339, 396-397.

Epstein, D. & Miller, R. T. (2011). *Slow off the Mark: Elementary School Teachers and the Crisis in Science, Technology, Engineering, and Math Education.* Center for American Progress.

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

Glaser, B. G. (1965). The constant comparative method of qualitative analysis. *Social problems,* 12, 436-445.

Harlen, W. & Holroyd, C. (1997). Primary teachers' understanding of concepts of science: Impact on confidence and teaching. *International journal of science education,* 19, 93-105.

Harlen, W. & James, M. (1997). Assessment and learning: differences and relationships between formative and summative assessment. *Assessment in Education: Principles, Policy & Practice,* 4, 365-379.

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.

Jones, M. G., Gardner, G. E., Robertson, L. & Robert, S. (2013). Science Professional Learning Communities: Beyond a singular view of teacher professional development. *International journal of science education,* 35, 1756-1774.

Kauffman, D., Johnson, S. M., Kardos, S. M., Liu, E. & Peske, H. G. (2002). Lost at sea": New teachers' experiences with curriculum and assessment. *Teachers College Record,* 104, 273-300.

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, 0013189X13480524.

Loucks-Horsley, S., Love, N., Stiles, K., Mundry, S. & Hewson, P. W. (2003). *Designing professional development for teachers of science and mathematics.* Thousand Oaks, CA: Corwin Press.

Magnusson, S. & Palinscar, A. (2005). Teaching to promote the development of scientific knowledge and reasoning about light at the elementary level. *National Research Council, How students learn: History, science, mathematics and science in the classroom,* 421-459.

Merriam, S. B. (1998). *Qualitative Research and Case Study Applications in Education.* Wiley.

Richardson, V. (1997). Constructivist teaching and teacher education: Theory and practice. *Constructivist teacher education: Building a world of new understandings,* 3-14.

Richmond, G. & Manokore, V. (2011). Identifying elements critical for functional and sustainable professional learning communities. *Science Education,* 95, 543-570.

States, N. L. (2013). *Next generation science standards: For states, by states.* National Academies Press.

Strauss, A. & Corbin, J. (1990). *Basics of qualitative research,* Newbury Park, CA: Sage.

Tichnor-Wagner, A., Harrison, C. & Cohen-Vogel, L. (2016). Cultures of Learning in Effective High Schools. *Educational Administration Quarterly,* 0013161X16644957.

Vanblaere, B. & Devos, G. (2016). Relating school leadership to perceived professional learning community characteristics: A multilevel analysis. *Teaching and Teacher Education,* 57, 26-38.

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

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