Establishing a Community of Practice between an Elementary Educator and a Scientist as a Means of Professional Development

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ABSTRACT

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This dissertation reports on an ethnographic study to examine and detail emerging practices in a community of practice comprised of an elementary teacher and a scientist (microbiologist). The study was conducted in order to design a model for professional development. It also aimed to contribute to the limited research involving elementary educators and their work with scientists. Furthermore, extra attention was given to understanding how both the elementary teacher and the scientist benefitted from their participation in the community of practice created from working together in teaching and learning science as a form of professional development. This was in accordance with a community of practice framework, which details that a healthy community is one without a perception of hierarchy among members (Wenger, 1998).

The elementary teacher and scientist as participants collaborated in the creation of a science unit for an afterschool program. A wide variety of data was collected, including: interviews, transcribed meetings, and online journals from both participants. The data was coded for reoccurring themes surrounding practices and shifts in perception about science teaching and learning that emerged from this community of practice as professional development. The findings have implications for practices that could be

used as a foundational structure in future collaborations involving elementary teachers and scientists for elementary science professional development.

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Acknowledgements

This dissertation focuses on the importance of community practices. In many ways, this dissertation is a product of a community. The support, guidance, and patience of the individuals mentioned below, allowed an idea in my head to develop into a fruitful and documented experience, which I will always cherish.

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CHAPTER I

INTRODUCTION

As a pre-service teacher in a Masters program, the idea of omitting science from my elementary classroom teaching seemed unimaginable and unacceptable. However, that quickly became the reality due to my having to manage all the difficulties of having my own class. I did what any first year teacher did: survive, fail, try again, recalculate and connect (Huberman, 1989; Ryan, 1986). I did not think about science and barely taught it – a surprisingly easy task, due to the heavy focus on literary and mathematics testing in elementary schools (Berg & Mensah, 2014; Rivera Maulucci, 2010; Spillane, Diamond, Walker, Halverson, & Jita, 2001). I did not think it was part of my role as a teacher to teach science, nor did I perceive myself as a science teacher or a member of the scientific community, so I did not teach science. When I reflected back on that first year, I realized the injustice that had been done. How did I become another teacher in an underserved area who did not teach science? How did I become part of the problem? How did I let my own insecurities and inabilities invade my classroom? I knew I needed to do something. It was not my strength in science or my love for the topic that made me focus on science teaching. Rather, I always knew I wanted to work in and serve underserved areas and this was an underserved subject (Rivera Maulucci, 2010; Spillane et al., 2001).

The launching point for this research is my experience being an outsider in the scientific community. I began to look into research surrounding the improvement of science education. In general, these ubiquitous reforms all tend to target changes in curriculum with less of a focus on the people delivering the curriculum – the teachers (Kelly & Ponder, 1997). Perhaps the solution lies in seeing the reciprocal nature *between* curriculum and pedagogy.

This requires an understanding of how the curriculum is carried out, shaped, and informed by the educators (Doyle, 1992). With this understanding, shaping education means understanding, supporting and developing teachers. Research should view teachers as learners (Spillane, 2000). This will grant not only a superficial understanding of educators, but a more in depth look at their knowledge, their identity, and their sense of belonging (Moore, 2008).

It is this sense of belonging that was always in the back of my mind. The separation between general education teachers and science teachers, elementary teachers and high school teachers, and teachers and scientists has always weighed on me. It was not until I read *Situated Learning: Legitimate Peripheral Participation* (Lave & Wenger, 1991) and learned about communities of practice that everything fell into place. I saw how identities were shaped and how communities provided a forum for an exchange of knowledge and a sense of belonging. It should be noted that Lave and Wenger's original work was not focused on educational communities. Their writing intended to explore knowledge as something that is situated and distributed within a community. Their work has been applied towards the understanding of organizational managements, online communities, and a variety of other group-based learning centered on a common interest or goal. I saw how the formulation of communities of practice could be applied to support teachers in an educational community for science teaching and learning. As the idea percolated in my mind, I wondered about implementing communities of practice to support members *within* a practicing community, and also *link* two communities that seemingly exist in insolation: elementary educators and scientists.

The involvement of scientists in the advancement of science education is not a new practice. In the past, scientists have led professional development workshops for teachers (National Research Council, 1996) and provided content support on science curriculum development (Linn, 1995). Most “partnerships” have been characterized by scientists providing science content matter, which educators then used to design lessons (Halversen & Tran 2010). My goal was not to study an already existing and developed community of practice, but to bring together members of two existing communities and nurture a new community of practice (Wenger, 1998).

Rationale

My goal has been, and will always be, to improve science education for the benefit of all students. This is a lofty task considering that there are so many factors contributing to a child’s education; most are impossible to control as every child is different. Yet there is one commonality: every child has a teacher. When I think about strengthening schools, preparing our teachers to be better at educating students is at the forefront. This does not shift the responsibility completely to the educators, but it makes sense to properly equip teachers who are on the front lines and contributing daily to the service of teaching, preparing, and caring for their students.

The concept of bringing scientists and teachers together is not a novel one. The National Research Council (NRC) (1997) supported this method as a way in which teachers can gain more experience and comfort with science. However, these “partnerships” have mostly been in the form of scientist-led workshops for middle school and high school educators (Moldwin et al., 2007). Research exploring the experiences and professional development of middle school and high school educators does not transfer into an understanding of an elementary educator. Elementary educators are generalists, meaning that they are required to teach multiple subjects without having a degree or focus in any subject in particular. As generalists, most elementary educators have limited science learning in their educational backgrounds and undefined subject matter specializations (Berg& Mensah, 2014; Spillane et al., 2001). In fact, elementary teachers in particular have limited exposure to science after high school (Raizen & Michelsohn, 1994), and elementary school teachers are lacking both content and understanding of science and the nature of science (NOS) (Abd-El-Khalick & Lederman, 2000). Furthermore, developing a teacher's understanding of NOS does not necessarily translate into her pedagogical practices (Akerson & Abd-El-Khalick, 2003). Therefore, elementary teachers have different professional development needs than middle school and high school educators (Appleton, 2005; Tytler, 2007). The purpose of this research is to determine how working with a scientist and forming a community of practice can meet the professional needs of elementary educators. Studies involving middle school and high school teachers' collaboration with scientists were still taken into account when determining effective practices (establishing goals, consistent meeting times, etc.). These practices were implemented early on as the foundation of the elementary teacher- scientist community.

Scientists are often required to share their work with a larger audience, including college students, conference attendees, and fellow scientists. Yet they rarely receive any pedagogical training that would allow them to share their ideas effectively (Handelsman, Miller, & Pfund, 2007). Past research in which scientists co-taught courses with middle school and high school teachers have indicated that these partnerships had various benefits for the scientists. For example, Halversen and Tran (2010) identified benefits for scientists that included drawing on their content knowledge, thinking of multiple ways of presenting information, and refining methods of communication. Once again, these benefits were identified while working with non-elementary educators and informal science teachers.

This study identifies the benefits of working with elementary educators, who generally demonstrate a good range of pedagogical skills as generalists but lack the science content and confidence to apply their skills in a science context (Hudson, 2005). The goal of this research was to develop a professional development model that would address the needs of the elementary education and scientific communities through a collaborative and supportive community of practice. The following research questions were addressed:

- What are the characteristics of a teacher-scientist community of practice (i.e. shared repertoire)?
- How does participation in the community of practice affect the members' perceptions of one another?
- What practices are mutually beneficial in an elementary educator- scientist community of practice as a means of professional development?
- How can practices be brokered to overcome boundaries between the education and scientific community?

Structure of Dissertation

The dissertation begins by outlining my personal journey from elementary generalist into science educator. In Chapter 2, I review the background literature for this study, as well as offer my theoretical frameworks. This literature highlights issues surrounding elementary teacher education in the field of science. I also present the general components of a community of practice, as they would apply to any field, and the benefits of using communities of practice for engaging in this particular study. I then offer a review that is more specific to my study as I move from the use of communities of practices as a professional model for teacher development and finally the literature pertaining to partnerships between teachers and scientists.

Chapter 3 provides details on methods and methodology for this study. I provide an explanation as to why this study lends itself best to qualitative research, more specifically an ethnographic study. I also describe my role as observer and how my self-perception defines my roles in this research. I describe the model for the study and opportunities of teacher-scientist interaction. Elements of credibility, validity, and rigor are drawn upon from the research of Guba and Lincoln (1989) as I detail the analysis of my various data sources.

The findings of this dissertation are written in the format of two distinct and publishable papers (Chapters 4 and 5), though without the references. (All references are contained at the end of the dissertation). Chapter 4 addresses the findings surrounding practices that were established by the teacher and the scientists as part of their emerging community. It recognizes findings as boundary practices (Wenger, 1998) that either draw upon common practices from their respective communities or created new shared repertoire to address the needs of their new community.

The second paper (Chapter 5) focuses on the use of analogies as a means of communication between the teacher and the scientist. In Chapter 5, I demonstrate the journey that the teacher and the scientist underwent to establish a method that would clarify complex and abstract scientific concepts. The participants are quoted numerous times in order to capture their voices and the details of their discourse.

Finally, Chapter 6 revisits all of the findings of the dissertation. In this chapter, the theoretical frameworks are explored and applied to the findings. Limitations, implications and recommendation for future research are discussed.

Table 1 :Overview of Chapters

Chapter	Chapter Focus
1	Introduction and research rationale
2	Literature review and theoretical framework
3	Methods

4	Questions Addressed: What are the characteristics of a teacher-scientist community of practice (i.e. shared repertoire)? How does participation in the community of practice impact the members' perceptions of one another?
5	Questions Addressed: What practices are mutually beneficial in an elementary educator- scientist community of practice as a means of professional development? How can practices be brokered to overcome boundaries between the education and scientific community?
6	Discussion and Conclusions

Chapter II

LITERATURE REVIEW & THEORETICAL FRAMEWORK

Challenges of Elementary School Science Education: Examining the Issue

Asking elementary teachers to teach science and actually preparing them to do so involve two completely different challenges. If teachers are not familiar with what they are teaching in science, due to a lack of sufficient preparation and professional development, then that could be the first shaking domino in a series that results in an unstable structure in our science education system. The root of the issue could be one that stems deep into the teacher's own science education and is passed on in their own teaching (Hawkins, 1990; Mensah, 2011). Elementary school teachers generally have had a negative experience with science from their own education (Abd-El-Khalick & Lederman, 2000; Appleton, 2006), which can be seen in drawings, descriptions, and conversations of past science learning experiences (Mensah, 2011). Furthermore, they see science education as it was presented to them as students. These negative experiences cause them to avoid science courses when given the chance, after high school and in their tertiary study. This avoidance of science results in limited content knowledge and results in a tendency for elementary school teachers to prefer non-science subject areas (Appleton, 2006). Abell and Roth's (1992) research has shown that the lack of science content knowledge among elementary school teachers has resulted in low confidence to teach science. They begin to formulate a perception of science that does not include their own participation within it; science is seen as a collection of laws and theories (Abell & Roth, 1992).

As a result of their own negative experiences, many elementary school teachers avoid teaching science altogether or teach science using pedagogical strategies more conducive to learning of other subject areas (Appleton, 2006). They are able to avoid teaching science because of the low priority that schools place on science as compared to other subjects (Berg & Mensah, 2014). High stakes testing pressures elementary schools to perform well on literacy and mathematics and therefore science is not as strongly emphasized (Mensah, 2010; Spillane et al., 2001).

Despite negative experiences, one would think that requirements in teacher preparation programs would give pre-service educators no choice but to take courses that would prepare them for the teaching of science. However, that is not the case. State and institutional requirements vary in specifics, but the overall number of hours required of pre-service teachers in the area of science is less than ten hours (Kelly, 2000), thus leaving teachers with a less-than-solid scientific understanding, based on their K-12 experience in conjunction with their teacher education programs. Furthermore, according to Akerson, Cullen and Hanson (2009), the majority of elementary teacher preparation programs do not offer a Nature of Science (NOS) course, which is critical to truly understanding science and communicating it to students (Lederman, 1999).

Teacher professional development has come under the microscope as studies show that student achievement is linked to teacher expertise (Loucks-Horsley & Matsumoto, 1999). Darling-Hammond (1998) cites teacher knowledge of content and teaching methods as a characteristic of teacher effectiveness. Darling-Hammond also concludes that these skills are not innate; therefore, teachers must be immersed in teacher professional development opportunities and effective teacher education programs in order to build content and pedagogy.

What is a Community of Practice?

"Communities of practice are an integral part of our daily lives. They are so informal and so pervasive that they rarely come into explicit focus, but for the same reasons they are also quite familiar" (Wenger, 1998, p. 7). While a community of practice can take on various forms, it is generally recognized as a group of individuals united over a common interest, goal, or task. They generally have an interest or passion for the same topic and deepen their knowledge of that topic by interacting with one another (Wenger, McDermott, & Snyder, 2002). A community of practice can be as formal as a graduate course or as informal as a knitting club. Despite their ubiquitous nature, communities of practice have a complex composition. Access within a community can be limited, and identities within them are constantly being shaped and negotiated.

The learning theory of Legitimate Peripheral Participation (LPP) as explained by Lave and Wenger (1991) proposes that a learner is not merely gaining information, but is also gaining membership into a community of practice. As new membership is gained, newcomers within the community transition into becoming the old-timers. This transition is the reason behind the "peripheral" aspect of the theory. The newcomer is seen as someone coming in at the edge of the community of practice and moving towards the inner works of the practicing community. It must be noted that while there is a "peripheral" aspect, there is no actual "center," as one figure is not seen as a center for a community of practice; knowledge is always developing (Lave & Wenger, 1991). More accurately, it is a transition from peripheral participation to full participation.

Membership into a community can be characterized by three dimensions (Wenger, 1998). These include *mutual engagement*, *joint enterprise*, and *shared repertoire*. *Mutual engagement* is a major constituent of communities of practice because without the interaction between individuals it would not qualify as a community of practice. Wenger emphasizes that the term *communities of practice* does not simply imply a group of people that come together or declare their membership to an organization. Rather, it is the engagement between the individuals within a group that truly define it as a community of practice. Therefore, maintaining a healthy and functional community of practice entails anything that would foster mutual engagement. This means being in the know and being included in what matters. A teacher who only knows what is happening in her class – without any indication of what is going on throughout the entire school – will not have a sense of belonging and, therefore, will not develop an identity as an active participant in the school community.

Diversity within a community is also essential for *mutual engagement*. This refers to the diversity of the roles within the community, and how they interact with one another. For example, within a school, a teacher might interact with the principal, teachers in different grades, staff developers, and custodial staff. As individuals within a community interact, they form an identity because they solidify who they are, their knowledge, and the purpose they serve. The act of engaging others results with the members of a community identifying who they are.

Second, *joint enterprise* is another component of community of practice. This refers to a product that results from the members of the community coming together and negotiating meaning in order to achieve a common task. The members must come together in order to achieve a goal, whether or not it is something they agree upon or share the same passion towards. Once again, this brings to the spotlight the importance of heterogeneity within the community.

The third component of community, as it relates to practice, is *shared repertoire*. "It includes the discourse by which members create meaningful statements about the world, as well as the styles by which they express their forms of membership and their identities as members" (Wenger, 1998, p. 83). These repertories are a result of participative (social and active process of constructing meaning) and reificative practices (negotiating meaning to make the abstract concrete). Basically, being a part of a community of practice means being able to "walk the walk" and "talk the talk."

As an alternative to being a complete member of a community, practice can also provide connections and help manage boundaries. This can be done in the following two ways: boundary practices and overlaps (Wenger, 1998).

Boundary practices occur when two communities of practice interact on a common task. Each community gets to maintain its own culture and set of practices, but they are united by a common enterprise. When *overlaps* occur, there is also an interaction between two communities; however, there is no specific enterprise that acts as catalyst.

For the purpose of this research, I argue that the interaction between an elementary educator and a scientist will initially be a joint enterprise, but continued interaction will result in a new community of practice in which practices and shared repertoire are created.

Research in Communities of Practice and Teacher Development

In order to gain a more comprehensive understanding of the existing research surrounding communities of practice and teacher development, the term "communities of practice" needs to be expanded upon. Communities of practice are so various and exist under so many different conditions that researchers have identified them in their research under different terms. Wenger, McDermott, and Snyder (2002) explain that communities of practice can be:

- Small or big: Although the quantity of membership affects the structure of the community, it can still be any size.

- Long-lived or short-lived
- Co-located or Distributed: Although most communities form because of proximity, they can still be distributed because there are other various methods for communication.
- Homogeneous or heterogeneous: Coming together for a common goal or problem can unite people of different functions and roles.
- Spontaneous or intentional

Although they do not refer to a community of practice, or use the terminology of *newcomer* and *old-timer*, Cochran and Smith (1999) proposed a model for teacher development that is very comparable to communities of practice. They make a distinction between three types of knowledge: knowledge-*for*-practice, knowledge-*in*-practice and knowledge-*of*-practice. Knowledge-*for*-practice refers to the theoretical and formal knowledge surrounding practices of teaching. Knowledge-*for*-practice refers to a knowledge that moves beyond the theoretical and encompasses what teachers perceive as more practical knowledge. Knowledge-*in*-practice is the type of knowledge that arises when teachers treat their classrooms as sites for investigation of successful pedagogical practices. This type of knowledge links to communities of practice as Cochran and Smith suggest setting up teacher groups comprised of teachers of varying experiences so that they can exchange ideas, reflect on their practice, and share knowledge.

Lesson studies can also be perceived as a community of practice. Lesson studies have been implemented from elementary to post-secondary education (Cerbin & Kopp, 2006). In this practice, a lesson is analyzed and “perfected” by a team of educators and taught multiple times (Chokshi & Fernandez, 2004). Because the educators are uniting around a common goal and interest, then the members of a lesson study could certainly be considered a community of practice.

Workplace communities of practice have been heavily researched and documented, but this area does not generally include teacher education and development (Schlager & Fusco, 2003). However, there are points in which communities of practice have been specifically cited as a model for education in research. Akerson et al. (2009) describe one such study. In this study, a community of practice was implemented in order to improve teachers' understanding of the Nature of Science (NOS). This study involved nine elementary educators from different schools. In order to address the ineffectiveness of one-shot workshops (Lumpe, 2007), the Akerson and colleagues conducted sessions that spanned two weeks in the summer and continued with monthly trainings during the school year. The program focused on providing the participants with physical science content to address elementary educators' lack of knowledge in that area (Kruger, Palacio, & Summers, 1992). In order to nurture a community of practice, the teachers were given an opportunity to share their knowledge, reflect on their learning, and provide their unique experiences. Findings indicated that communities of practice could not stand alone to provide teachers with a strong understanding of the NOS. Recommendations included identifying areas of content confusion and addressing them within the community of practice. Another suggestion included giving opportunities for the discussions between communities of practice to continue outside of the professional development. Akerson et al. recommend online discussions as a forum to facilitate these discussions. These recommendations are taken into account in my research design and discussed in further detail in Chapter 3 on methodology.

Also using technology to nurture communities of practice, Schlager and Fusco (2003) aimed to design an online system specifically with teacher communities in mind. While there have been other online programs that link communities, Schlager and Fusco felt the need to identify the specific needs and characteristics of an educational community. They expressed that the educational community was different in terms of its history, repertoire, and the variation in expertise and focuses that existed within the field. Schlager and Fusco maintain that within educational communities of practice, members take on multiple roles (i.e., mentor, mentee, coach, leader--and, of course, everyone is also everyone else's research subject), and an effective online communication system should allow them to take on the various roles and identities.

Roberts and Pruitt (2009) go into great depth about what I perceive to be the implementation of learning communities within a school. However, the term "communities of practice" is never actually used. Rather, Roberts and Pruitt use the term *learning communities*. Just like the communities of practice, a learning community involves a group of individuals sharing ideas and working together to achieve a common goal. When correctly implemented in a school, teachers and other members of the school community see themselves as learners. Reflection is one of the key characteristics of the learning communities. Teachers are encouraged to work together in grade teams as well as cross-grade teams to share information and reflect on their practices.

Therefore, in this section an overview of the research on the development of communities of practices within the educational system is discussed. In general, the benefits have been allowing members to support each other, exchange ideas, and develop and implement knowledge outside of traditional one-shot, one-day workshops. My focus is on linking two communities of practice – elementary teachers and scientists—for the benefit of the participants and students in the long run. The next section focuses specifically on previous research surrounding benefits of collaboration between teachers and scientists for teacher professional development.

Benefits of Communities of Practice for Teacher Development

Sending teachers to workshops has become the go-to method of developing in-service educators (Lumpe, 2007). Millions of dollars have been utilized, but the benefits of the workshop models are not in alignment with the hefty investment. Teachers rarely utilize their newfound knowledge gained from the workshops (Lumpe, 2007). Of workshop models, Lumpe writes:

> Teachers dutifully attended, received their stipends, and returned to the classroom with little support and scant application. The impact on students was hardly worth the millions of dollars… workshop models of professional development remain prevalent because they are efficient. (p. 125)

This does not mean that all workshops must be scrapped. Rather, something needs to be implemented to pick up where workshops leave off: recognizing and tackling other issues in teacher knowledge and identity that workshop models do not address. I am proposing that one of those methods should be a community of practice model between teachers and scientists (at times extended to the students) within a school. This section focuses on the benefits of a community of practice model.

Teacher Identity

Legitimate Peripheral Participation (Lave & Wenger, 1991) is *not* a pedagogical theory. However, it has been used to form a better understanding of how teachers are developing technique, gaining knowledge, and growing professionally during, and after, their first year of induction into the community. To clarify, it is not used to analyze pedagogy, as one might assume when teacher education is involved, but rather to better understand teachers as learners and as those entering a community of practice.

Kelly (2006) explains the challenges that researchers face when trying to understand teacher education and professional development. Among these challenges are theoretical frameworks that neglect to simultaneously consider how teachers gain knowledge and how they apply it; they treat them as two independent entities. Kelly notes how these challenges in research are addressed by applying the work of Lave and Wenger (1991). Their understanding of LPP accounts for situated learning and considers the developing identities of the teachers within a community of practice.

Not a Hierarchy

While communities of practice often occur spontaneously, there have been attempts to formalize the transition from newcomer to old-timer in the form of mentoring. Mentoring has been seen as a method of training novice teachers (Odell & Farrero, 1992; Smith & Ingersoll, 2004). The mentoring relationship between novice and expert teacher might seem disproportionate in terms of power dynamics. However, in order for the apprenticeship relationship to be successful there must be a flow of knowledge and support. There must be less of an emphasis on conforming, which is generally the case in a school that is bureaucratic and hierarchical (Harrison, Lawson, & Wortley, 2005). This is a school in which decisions are made from the top down and teachers are not given an opportunity to voice their opinions or needs. Bureaucratic and hierarchical school environments can limit access to teachers and stunt teacher development (Harrison et al., 2005). The notion of access is discussed by Lave and Wenger (1991) because without granted access by the old-timers in the community, one cannot truly gain peripheral participation.

While mentoring has proven to be an effective method for teacher development (Odell & Farrero, 1992; Smith & Ingersoll, 2004), the delicate relationship between mentor and mentee could become too personal, resulting in a power struggle, or leading to restricted access. The mentor teacher could indeed take on a "central" role in the process and, as previously discussed, Lave and Wenger (1991) believe that true LPP does not involve a central figure.

As an alternative to the apprentice/master relationship, a community of practice could be one of practicing teachers supporting each other. Hodkinson and Hodkinson (2010) describe one such case of members supporting each other in a community of practice. They studied a group of middle school teachers as they supported each other, shared knowledge and resources, and helped each other improve their pedagogical practice. In this case, the teachers were not *newcomers* to the community of practice, but rather established *old-timers.* Hodkinson and Hodkinson concluded "legitimate peripheral participation is not necessary, or even always the dominant component of learning in communities of practice" (p.16). Teacher development was seen as stemming out of an already existing community of practice, something not thoroughly discussed in Lave and Wenger's 1991 publication. In a later publication, Wenger (1998) sheds more light on this by explaining:

> Communities of practice reproduce their membership in the same way that they come about in the first place. They share their competence with new generations through a version of the same process by which they develop. Special measures may be taken to open up practice to newcomers, but the process of learning is not essentially different. (p. 102)

This is a departure from focusing on *newcomers* coming into a community of *old-timers.* It puts more of a focus on the interactions between *newcomer*s and *old-timers,* and even simply among *old-timers.* These interactions are how the community of practice evolves by sharing and developing knowledge (Wenger, 1998). This suggests the need for teachers to be welcomed into the community of practice upon entrance into the community, and also for them to continue interactions with members of the practicing teacher community. As mentioned earlier, this would involve a learning environment that is conducive to teacher learning, not one that is power oriented.

Literature Review of Work Involving Teachers and Scientists

The nature of these work experiences or collaborations is various; the most common form of teacher-scientist interaction has been in the form of internships and workshops (Gottfried, Brown, Markovits & Changar, 1993). Teachers are sent outside of schools to the scientists' place of practice, where they are expected to learn scientific practices and content in workshops led by scientists (Anderson, 1993). Findings from these studies indicated that there was an increased content matter understanding as well as construction of practical activities.

Interaction between teachers and scientist does not constitute collaboration because of sheer proximity. There was always an underlying perception that the scientists were more knowledgeable and higher up the hierarchy because they were leading the workshop and helping the educators in an area of perceived weakness (Caton, Brewer & Brown, 2000). The formations of hierarchies prevent a healthy community of practice or collaborative relationship from developing (Million & Vare, 1997; Wenger, 1998). As a result studies have been focused on identifying and preventing rankings or the development of hierarchies among K-12 educators and scientists within a professional development model.

The workshops model and communication of goals emerged in the research as the two major methods of preventing the formation of hierarchies. Identifying and communicating goals within the community (Abell, 2000) allowed everybody to understand what each person is working on individually and how they come together collectively. Furthermore, sending teachers outside for science professional development was sending the message that science was situated outside of the school. Finally, the scientist-led workshops left the teachers disempowered, without a sense that they were contributing.

Theoretical Framework

To frame my research, I draw on three different theoretical perspectives that complement one another, as well as intertwine at various key points. These perspectives include: communities of practice, subject matter identity, and Carlone and Johnson's Model of Science Identity. These five help me to gain insight into the identities of my participants and their roles as members of a community.

Communities of Practice

Communities of practice, as a theoretical framework, offers insight on my participants' trajectory from outsiders (non-participation) to members within a community. I approach this with the understanding that membership can range from peripheral to full participation (Wenger, 1998). Furthermore, this study recognizes that knowledge is situated within an experience or community; it does not exist in isolation (Lave & Wenger, 1991). I also recognize that boundary practices exist when two communities come together (Wenger, 1998) and that a successful community of practice is one in which all the members feel that they are both contributing and benefiting (Wenger et. al, 2002).

Subject Matter Identity

Subject matter identity also acts as a theoretical framework for this study. Elementary school teachers are very different from secondary and high school teachers, as they teach various subjects and normally do not specialize in any one subject matter. Friesen, Finney, and Krentz (1999) wrote, “Teacher identity involves more than simply taking on a prescribed role that supposedly fits all teaching situations. Therefore, we would expect that [teacher] identity would be shaped differently in different teaching situations” (p. 925). Hence, when looking at teacher identity, one must also take into account that that same identity may vary depending on the subject matter being taught. For instance, Helms (1998) looked at the personal and professional sense of self in secondary school science teachers. Each subject matter comes with a set of affiliations, beliefs, values, discourse and identity. These factors are very similar to being a member of a community of practice (Wenger, 1998). How is an elementary school teacher supposed to develop an identity that fully encompasses all of these elements, for each of the subject matters she teaches? For this reason, subject matter identity is an appropriate theoretical framework to frame research involving elementary educators.

The use of analogies in science education has been identified as one of the many effective practices that could possibly be encompassed as part of a science teacher’s methods for explaining scientific concepts (Guerra-Ramos, 2010). This is a form of discourse that is fine-tuned and practiced as part of one’s subject matter identity, specifically discourse. I mention analogies specifically as a component of subject matter identity as it is a form of discourse that will prevail as a successful means of communication in the community of practice. Under the lens of Subject Matter Identity, it is not perceived simply as a useful practice, but a means of communication that is part of the participant’s professional identity

Model of Science Identity

Carlone and Johnson (2007) draw upon Gee's Theory of Identity in order to create their own science identity model. Gee's Theory of Identity (2000) is an understanding that identity can be viewed from four different positions: Nature, Initiation, Discourse, and Affinity Identity. Gee proposed that identities are who we are because others recognize us as such. In order for one to be a "certain type of person" one must behave in a certain way and be recognized by others. An Affinity Perspective in research focuses on the practices that enable an individual to gain or maintain an affiliation with a group. Carlone and Johnson implement Gee's model in order to analyze 15 women of color whom they identified as successful in the field of science. They then identified three dimensions of science identity: competence, performance, and recognition. Carlone and Johnson stated that one who sees themselves strongly as a "science person" rates themselves high in these three fields. Furthermore, since identity is recognized by others (Gee, 2000; Wenger, 1998), Carlone and Johnson's model of science identity also considered how others perceived their participants under these three dimensions. Moreover, one can actually have a strong knowledge and understanding of science (competence) and exhibit comfort in scientific practices (performance) but still not be recognized by others in the field of science. This is important to my research because I focus on these three dimensions when interviewing participants about their developing identity, but also how they perceive one another.

Once more, the research questions for this study are:

- What are the characteristics of a teacher-scientist community of practice (i.e. shared repertoire)?
- How does participation in the community of practice affect the members' perceptions of one another?

- What practices are mutually beneficial in an elementary educator- scientist community of practice as a means of professional development?

- How can practices be brokered to overcome boundaries between the education and scientific community?

Chapter III

METHODS

Qualitative Research Approach

My goal to bring together the scientific community of practice with the elementary education communities (i.e., multiple subject areas) of practice is, in essence, the merging of two cultures. Qualitative research was then appropriate because it allowed me, as a researcher, to understand how my participants "interpret their experiences, how they construct their world, and what meaning they attached to their experiences" (Merriam, 1998, p. 5). Each community of practice has its own set of practices (Wenger, 1998). This partnership between teacher and scientist, hopefully, helps each to share and expand on these practices.

Ethnography

Ethnography, as a method, is fitting because it seeks to shed light on the practices of the communities being studied (Merriam, 1998). This methodology allowed me to observe and report back on teachers-scientists interacting in their settings, and keep the study flexible to allow for their relationship to develop naturally (Merriam, 2009). This method also allowed me to stay true to my theoretical perspective and research questions, as it lends itself to developing an understanding of identity formation.

As an ethnographic study, the overall goal of this research was to gain a deeper understanding of the complexities and the culture that arises when a scientist and a teacher come together. The method of this research was to document their interactions, and the natural progression of their relationship, with aims to identify strengths and limitations of their developing a community of practice. Moreover, the purpose of this was to establish a model for professional development for both elementary educator and scientist. This included identifying best practices in which content knowledge and pedagogical skills are shared and developed.

Selection of Participants

The participants for this study volunteered to be part of the research after informally hearing about the study. I accepted them as participants because they fit the criteria for the research.

Criteria for Teacher Selection The teacher participant must be an elementary educator teaching in a multi-subject classroom. She/he must also have a (perceived) limited background in science. The educator should be one that is seeking to grow as a science educator and is open to reflection of her practice. She/he must also express a general discomfort with teaching science as compared to other subjects. The educator must be confident in her/his pedagogical practices otherwise. Additional pertinent details are presented in the methods section of the publishable papers presented in the Results Chapter.

Selected Teacher Alison is a lower elementary teacher who has been teaching for five years. She holds a Master's degree in elementary education with a specialty in literacy and certificate in gifted education. She teaches at a K-8 private school, in which she is a generalist and co-teaches kindergarten. Alison also teaches yoga and physical education as part of the afterschool program. Prior to becoming a science teacher, I was on the kindergarten team with Alison for three years. Alison qualified for this research as she perceived herself as a skilled educator and was confident in her overall pedagogical skills. Her goal for this research was to gain confidence in the teaching of science by gaining content knowledge and more experience with teaching elementary science.

Criteria for Scientist Selection In other studies I reviewed that involved teacher-scientist partnerships, there was no criterion for the selection of the scientist. The scientist is generally chosen based on area of study. However, I feel that in order for this partnership to function, the scientist must also be selected based on a certain set of criteria. The scientist must also be entering the study seeking to gain something out of it. This is also a growth opportunity for the scientist; the scientist must feel that he has something to contribute to the partnership as well as something to gain from discussions of science and pedagogy. The selected scientist was neither a member of my thesis committee nor a faculty member at Teachers College.

Selected Scientist Daniel is a microbiologist who has been in the field for over 30 years. He works predominantly in a laboratory, but teaches undergraduate and graduate-level science courses. Daniel has published more than two-dozen articles in scientific journals. Almost all of his publications have been collaborative efforts, as Daniel highly values fellow scientists and often discusses their work as part of this study. Daniel entered this research with the goal of gaining pedagogical methods that would allow him to promote the cultivation of questions when he teaches and improve his communication skills.

Research Setting

The site for this study was a private school in which I am currently employed. I feel that this gives me deeper access into the elementary school community, but I am removed enough from the teacher participant as we do not generally interact as part of our daily professional duties. This is in accordance with my ethnographic approach in which cultures are studied in their natural place of practice. Therefore, this research brings the scientist into the elementary school classroom, whereas most formal professional developments in the field of educations take place outside of the teacher's place of practice (Stein, Smith, & Silver 1999). This also avoids establishing the notion that scientific knowledge and practice is situated outside the school walls. The scientist and the teacher worked together to plan lessons as content knowledge was developed. This created a unity between knowledge and practice, as knowledge acquisition and unit design occurred simultaneously. This model is in accordance with Lave and Wenger's (1991) writing on communities of practice. Conducting this study in the scientist's place of work might have situated scientific practice and learning outside of the school, once again isolating the two communities (Wenger, 1998).

My Role in the Community

My own personal journey as an elementary educator led me to this study. Therefore, I feel that I play an important role in this community. As an elementary science teacher, I saw myself as the link between the two communities of practice. Yet, as this research was an ethnographic study, I recognized the importance of allowing the culture to develop. I wanted my participants to forge their own practice from within the community (Lave & Wenger, 1991); and, therefore my own practices were not imposed on them: I took an observer role.

Carlone and Webb's (2005) experience shaped my perceived role in this research. As previously discussed, avoiding a hierarchy was a priority in order to form a healthy community of practice and a successful professional development model. Therefore, I only planned on stepping in whenever I felt that a hierarchy was developing or if there was difficulty communicating goals.

Proposed Model

Scientist as workshop presenter and mentor has been the prominent model discussed in the literature (Drayton & Falk, 2006). However, a healthy community of practice is one in which all parties have something to contribute or a hierarchy will form and feelings of incompetence will transpire (Wenger et al., 2002). Admittedly, the model for this research study could not have been implemented with just *any* teacher and *any* scientist. The scientist could perceive himself as someone who is helping the teacher; a community cannot thrive if all members do not feel that they are benefiting. Therefore, the scientist would have to be seeking to develop his own practice, as is the case with the scientist involved in this research. Many scientists teach in colleges as part of their appointments but do not have any pedagogical training (Caton et al., 2000). The scientist stands to learn pedagogical practices from the teacher, such as scaffolding information, guiding students in reflection, time-management, differentiating instruction and other goals set forth by the scientist.

The purpose of their community was to design and teach a four-lesson mini-unit in an afterschool science program for a mixed kindergarten and first grade living environment class named "Zoology". The partnership took place over the course of a semester (September – December).

Data Sources

The data collection included many sources as products of the professional development model of the scientist and elementary teacher. These data sources are described below.

Entrance Interview: An entrance interview was conducted for both the scientist and the teacher in the science lab of the school. Each entrance interview lasted approximately one hour. Entrance interview questions can be found in Appendix A. Goals identified by both partners were compiled and shared in an email so that each participant established, early on, what each member of the community aimed to gain from participation in it (Wenger, 1998).

The entrance interview served to determine each participant's perceptions of themselves and their communities. During the entrance interviews each participant identified goals; these goals were compiled and shared with the other members. When members of the community of practice recognize the goals of others and understand that everybody hopes to gain from a partnership, then it results in a healthier and more balanced community of practice (Abell, 2000; Wenger, 1998).

Recorded Planning Sessions: Participants took part in an initial planning session to determine the overall theme of the unit, develop a plan for the first lesson and identify collaborative goals. Three additional meetings took place throughout the unit, immediately following the teaching of the lessons. Meetings focused on a transfer of knowledge-- content and practice. This transfer of knowledge is a key characteristic of a community of practice (Wenger, 1998). Establishing time for professional discussions was essential, as it is one of the features of a thriving learning community (Robert & Pruitt, 2009). During these meetings, the scientist informally explained science content and addressed the teacher's questions. I did not encourage any particular format for the meetings; meetings were flexible in order to promote development of ideas (Akerson et al., 2009). Participants met four times over one semester, which is the length of the afterschool program, to plan lessons and to share knowledge. The initial meeting was scheduled prior to the start of the lessons and the other three meetings took place after the first three lessons (the final lesson was reflected upon in exit interview). These meetings were audio recorded and transcribed.

Notes during Lessons: I took notes during the lessons as they were being taught. The purpose of these notes was to determine the questions for the reflection journals or to identify areas for discussion during the planning sessions. The scientist also attended the afterschool sessions when the lessons were taught, which was never the case when the workshop model was implemented outside of school. This allowed me to see how the knowledge transfers from the planning sessions into actual practice. I allowed my participants to determine what their roles would be when the lessons were being taught in order for them negotiate roles in accordance with their new membership in a teacher-scientist community.

Journal entries: The scientist and teacher were asked to keep journals to reflect on their meetings. Participants included any information they deemed relevant in their reflections. Additionally, I posed questions based on my observations in the lessons and during the planning sessions.

Emails between Participants: Discussions were continued informally through email correspondence to allow for ongoing conversations outside of the regularly scheduled meeting times (Akerson et. al, 2009). The teacher emailed the lesson plan prior to teaching the lesson. Email correspondence between the teacher and scientist was compiled and coded.

Exit Interview: Participants were interviewed a final time in order to identify any changes in perception or development since the entrance interview. In order to do this, the majority of the entrance interview questions were repeated, but additional questions were added based on what was observed during the partnership. Exit interview questions can be found in Appendix B.

Table 2: Data Sources for Research Questions

Research Questions	Data Source
What are the characteristics of a teacher-scientist community of practice (i.e. shared repertoire)?	• Entrance interviews • Exit interviews

	• Transcribed planning meetings • Journal entries
What practices are mutually beneficial in an elementary educator- scientist community of practice as a means of professional development?	• Entrance interviews • Exit interviews • Transcribed planning meetings • Journal entries
How does participation in the community of practice affect the members' perceptions of one another?	• Entrance interviews • Exit interviews • Transcribed planning meetings • Journal entries
How can practices be brokered to overcome boundaries between the education and scientific community?	• Entrance interviews • Exit interviews • Transcribed planning meetings • Journal entries

Data Analysis Methods

All audio records (entrance interviews, planning meetings, and exit interviews) were transcribed and coded using a Computer Assisted Qualitative Data Analysis Software (CAQDAS) called NVivo. NVivo allows for the creation of nodes as data is read in order to group common ideas together across various data sources. The nodes organize dialogue or written text directly from the participants into categories, so that they can further be analyzed for reoccurring themes or production of ideas. The process is outlined below in figure 1.

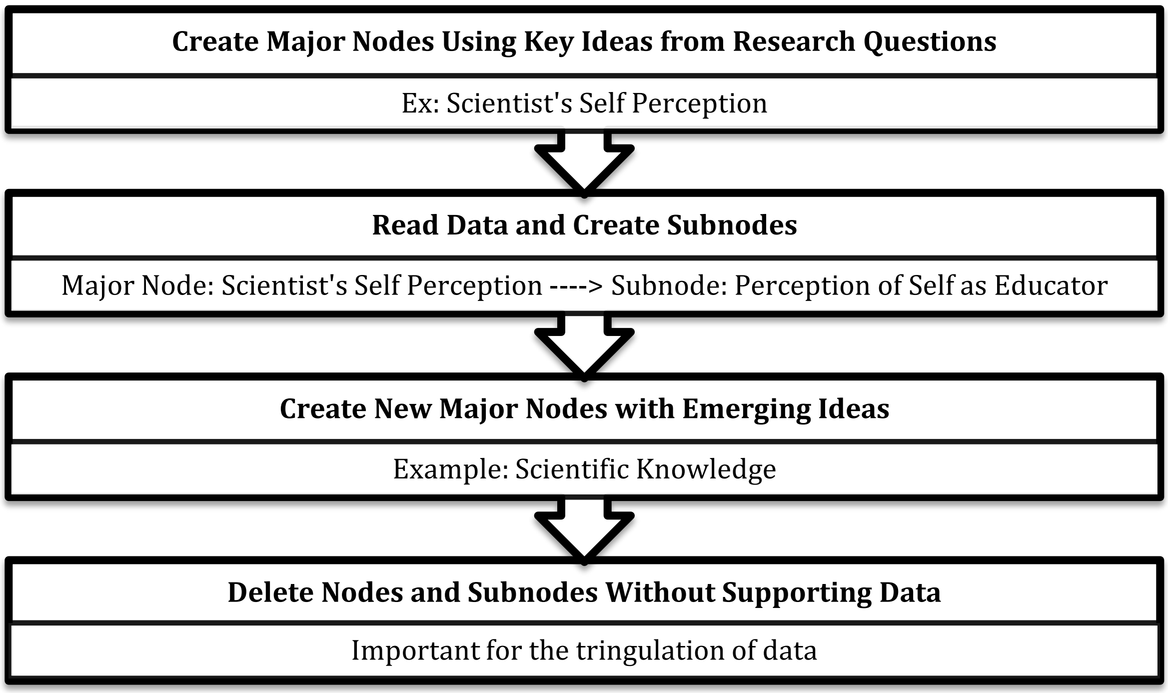


Figure 1: Outline of process for the creation of nodes and subnodes in NVivo for each participant

Validity and Rigor

The data collected in this study allowed for multiple opportunities and various forums for the participants to express their ideas, which allowed me to monitor shifts in perception and community development throughout the study. The entrance interview, the planning sessions, and the journal reflections provided varied, but consistent, data. Emails between participants allowed for a more spontaneous conversation and allowed me to remove myself from the role of interviewer or meeting facilitator.

All audio records (entrance interviews, planning meetings, and exit interviews) were transcribed. These data sources as well as interviews and notes were coded for common themes. The triangulation of the multiple sources helped assure internal validity (Merriam, 2009). The varied data sources (interviews, emails, journal entries, and field notes) and varied settings (science, at home reflections, interviews conducted outside of science lab) increased validity and rigor (Denzin, 1970).

Credibility

Member checks (correspondent validation) was used to assure credibility and validity (Merriam, 2009). This involved sharing findings with the participants of the study. If the teacher or scientist did not feel that they were accurately represented, then they were given an opportunity to respond to the conclusions and elaborate on their experience. Guba and Lincoln (1989) claim that member checks are the single most crucial method of credibility. They write, " If the evaluator wants to establish that the realities he or she presents are those that stakeholders have provided, the most certain test is verifying those multiple constructions with those who provide them" (p.239).

According to Guba and Lincoln (1989) member checks should be an ongoing process presented at various stages of the research progress. For this reason, the questions posed in the reflection journals are always determined after the lesson and planning period. In this way, the participants elaborated on comments made during meetings or the notes I took during the lesson. This insured credibility of both the data and the methods used to gather the information.

Ethics

The participants were given an overview of the research, and they both submitted a letter stating their willingness to participate in the research and their understanding that no information would be shared without their approval. Thus, the participants in the study willingly signed up based on their own interest for professional development. All data collection methods were shared with the participants in written form and questions were addressed prior to the study. Participants were aware of the opportunity for member checks as a means of elaborating on or elucidating any information.

Reflexivity

My own journey from elementary educator with no interest in science to a science educational researcher has brought me to this point. Therefore, I need to address role as researcher when collecting and analyzing data. Historically, the presence of the self in a research study has been perceived as a contaminant (Denzin & Lincoln, 1998). On the other hand qualitative research does not always benefit from a removed and omniscient writer (Creswell, 2007). Therefore, I felt that I needed to establish a set of guidelines for analyzing my data.

Denzin and Lincoln (1998) explain that the nature of the research and the historical marginalization of the participants should pave the way for defining the voice of the researcher. If the research participants have been marginalized and their voice has been historically silenced, the researcher should focus on making every attempt to capture their ideas exclusively. In that situation, a strong researcher presence deters from the goal of the research.

In the case of this research, I do not claim that either elementary teachers or scientists are historically marginalized. However, as previously discussed, the nature of the professional development regarding scientists and elementary educators has been hierarchal. Also, professional development general took place outside of school walls, which sends a message true scientific knowledge, must be sought outside a teacher's place of practice.

As an ethnographic researcher, I treated the newly formed community between teacher and scientist as a uniquely formed culture that I was witnessing but not practicing in.

Therefore, my voice as a researcher was more prevalent when analyzing data pertaining to teacher experience prior to entering the community. When it came to reporting on the newly formed community, I needed to focus on the data to minimize, if not eliminate, my own bias or desire for the outcome of the research. Yet, I did not think of this as removing myself from the data; rather, neutrality in qualitative research should be seen not as the neutrality of the researcher, but the neutrality of the data (Lincoln & Guba, 1985). This is all achieved via the increased rigor, which was discussed earlier.

Limitations

I have identified two limitations of this study, both of which I do not believe the study can address because the field is still missing the foundation in teacher-scientist communities. While there are studies that have linked teachers and scientists, the missing foundation that I am referring to in one in which these partnerships were cultivated as true communities in which all members are meant to benefit. The notion that only the teacher stands to benefit establishes a hierarchy and stunts development.

The limitations would be better addressed if the nature of the community of practice between teacher and scientist were better understood and a professional development model was already in place. One limitation of this research is that it does not examine the effects that the partnership has on student learning. The goal of teacher professional development is to make improvements for the benefit of student learning. However, this study only examines the impacts on the teacher and scientist.

Another limitation of this study is that it does not examine a community of practice with multiple teachers and/or multiple scientists. If this becomes a successful model for professional development, then more needs to be understood on how to expand the community of practice for the benefit of more individuals seeking to develop professionally.

Expected Contributions

The goal of this research was the development of a model of professional development for scientists (primarily those who teach or speak publicly about their research) and elementary educators. I hoped to create an opportunity for a new type of professional community to develop so that repertoire, practice, and methods of communication could be documented and better understood for use in future professional development. An underlying goal of this research was to contribute to research on teacher-scientists collaborations with a focus on the prevention of hierarchy through mutually beneficial practices.

Chapter IV

EMERGING PRACTICES WITHIN A TEACHER-SCIENTIST COMMUNITY

Abstract

In this study, I draw upon Communities of Practice as a theoretical framework to help establish a community between a teacher and a scientist. Carlone and Johnson's (2007) Model for Science Identity is also used to create an understanding of the individual professional needs of the members of the community as they negotiate roles and meet their identified goals. The participants included an elementary educator in her fifth year of teaching and a microbiologist with approximately thirty years experience in the field. They set out to create a science unit for a mixed kindergarten and first grade afterschool science program. Their interactions solidified the use of research based successful practices within a community and also manifested new practices, including: (a) pre-planning visit, (b) use of a personal topic of interests, (c) expansion of the community, and (d) negotiation of roles within the classroom. The findings of this study has implications identifying practices to be used in forging mutually beneficial communities between elementary educators and scientists as a means of strengthening both professions.
Keywords: communities of practice, elementary education, model for science identity, professional development, shared repertoire

Introduction

Educational researchers have identified a shortage in teacher-scientist professional developments on an elementary level and stressed the need to develop science in earlier grades (Duschl, Schweingruber, Shouse, 2007; Moldwin et al., 2007). Teacher-scientist experience programs have been used as a means of professional development since the mid-1980s (Gottfried, Brown, Markovits, & Changar, 1993). However, these science-work experiences, or collaborations between scientists and teachers, take on many forms. The most common forms are internships or workshop models (Gottfried et al., 1993). The goal of this study was to bring the scientist into the classroom with the understanding that their interaction would be professional development for *both* the scientist and teacher. It was essential for the professional development to be mutually beneficial to avoid the formation of hierarchy. The interaction between the teacher and the scientist was observed as a formation of a new community of practice (Lave and Wenger, 1991) with an emerging set of practices that allowed their community to function and develop. This study outlines these emerging practices that naturally occurred as the teacher and scientist worked together for a period of four months to plan a four-lesson mini unit. They negotiated roles, established communication and developed an understanding of one another's expertise.

Literature Review

There are studies that use a model similar to the characteristics of a community of practice as defined by Lave and Wenger (1991) without directly referring to the term community of practice. This could be due to the naturally occurring and ubiquitous nature of a community of practice; after all it is an umbrella term that is used to define the coming together of a variety of professionals, people, age groups, and an unlimited number of other combinations of individuals. Therefore, as part of the literature review, I define the foundational features of a community of practice, delve into how it has been applied directly and indirectly as a means of teacher professional development, and zoom in closer on teacher-scientist relations. I include studies that do not directly refer to communities of practice, but are still beneficial in understanding research preceding this study.

Characteristics of a Community of Practice

Legitimate peripheral participation (LPP), as described by Jean Lave and Etienne Wenger (1991), forms an understanding of a learner without losing sight of where that learning in situated. Therefore, the learner is not seen as one who is merely gaining information, but one who is gaining membership into a community of practice. Defining what a community of practice is can be difficult as it is meant as a term that encompasses the wide array of human interactions and dealings with one another; these dealings include our visceral and essential need to learn from others. However, the term cannot be left so open as to encompass any interaction and define it as a community of practice. The overarching characteristic of a community of practice, which must stay constant despite all other variables, is that it is comprised of a group of individuals with a common interest or passion. These individuals deepen their knowledge or skills by interacting with other members within the community. Wenger (1998) explores the number of individual collaborators and whether it impacts the formation of community. While the number of community members might call for different practices, there is no requisite minimum or maximum members. Larger groups can result in increased complexities when it comes to communication, division of roles, and other practices within the community. Wenger (1998) only states that a community of practice is comprised of two or more people, which is the case in this research study. While that alone can make a group of people (two or more) qualify as a community of practice, it does not imply that it is a healthy and functional community of practice. Wenger (1998) identifies three dimensions for a true and functional community of practice. These three dimensions include *mutual engagement*, *joint enterprise* and *shared repertoire*. Mutual engagement describes the interactions and relationships among the members of the community. Members cohere by having multiple opportunities, by working with each other, and by understanding the inner workings of their community. Individuals understand their unique roles in the community, but diversity within the community is also necessary. As individuals within a community interact, they form an identity because they solidify who they are, their knowledge, and the purpose they serve. The act of engaging others results in the members of a community identifying who they are and who they are not. Establishing mutual engagement is key in this study so that members do not get a sense of a hierarchy.

The common goal or interest is a seam that brings a community together. It can also bring two separate communities of practices together in what Wenger (1998) identifies as *joint enterprise.* This refers to a product that results from the members of the community coming together and negotiating meaning in order to achieve a common task. The members must come together in order to achieve a goal, whether or not it is something they agree upon or share the same passion towards. An example of this is a passionate artist and a writer coming together to work on a children's book. In this scenario, each get to maintain the practices of their own respective communities, but the book brings these communities together. Once again, this brings to the spotlight the importance of heterogeneity and diversity of skills within the community.

Shared repertoire describes the practices that develop within the community, which can include common tools, jargon, dress, rituals, procedures, etc. For the purpose of this research, I argue that the interaction between an elementary educator and a scientist is initially a *boundary encounter*, which is contact between two communities (Wenger, 1998). Continued interaction results in a new community of practice in which shared repertoire is created.

Elementary Educators Need for Science Professional Development

Elementary educators are generally a product of the shortcomings of their own science education (Abd-El-Khalick & Lederman, 2000; Appleton, 2006). Therefore, when generating an image of science, elementary pre-service teachers draw upon their own experiences with it, which tend to be negative (Mensah, 2011), isolating or even nonexistent. Compounding their negative feelings is an actual lack or insufficient content knowledge to teach science (Abell & Roth, 1992). The content knowledge shortage is not only a result of their own K-12 science education, but the problem is left unresolved as part of their teacher education programs (Kelly, 2000). While there *is* a small minority of elementary educators that are comfortable teaching science (Appleton, 2003), the majority avoids teaching the subject for the aforementioned reasons.

Shortcomings in the teacher's own science education prior to entering the classroom have resulted in a need to understand how elementary educators in particular practice science (Moldwin et al., 2007). This is opposed to most science education studies that tend to focus on middle or high school teachers, who have a completely different experience and set of tools for teaching science (Bell, Veal & Tippons, 1998). The current goal of the professional development of in-service elementary educators should be to develop teacher expertise and as a result increases student achievement in the subject (Loucks-Horsley & Matsumoto, 1999).

Teacher-Scientist Professional Development

The most common form of teacher-scientist interactions as a means of professional development has involved sending teachers to participate in scientist-led workshops in a lab or university setting (Anderson, 1993). Teachers reported back about their new content knowledge and findings, indicating that they had a better understanding of the content matter; they designed practical activities, and they shared these activities with colleagues who did not attend the workshops (Anderson, 1993; Caton, Brewer, & Brown, 2000; Varelas, House & Wenzel, 2005). Apprenticeships involved submerging the teachers in the scientific community so that they may pick up on scientific practice to incorporate in their teaching of science (Varelas et al., 2005).

Even when these workshop models and apprenticeships involved teachers and scientists, Caton et al. (2000) noted that the formation of hierarchies was a challenge that continually presented itself in teacher and scientist partnerships. Although the intention was to develop a collaborative partnership between scientists and teachers, the perception was that the scientists were helping the teachers and therefore the teachers relied on the scientists for direct instruction. These hierarchies prevent a healthy community of practice or collaborative relationships from forming (Million & Vare, 1997; Wenger, 1998).

Carlone and Webb (2005) write that Abell's study (2000) is the only self-reflective study involving an elementary teacher that has started to tackle the formation of hierarchy. Abell's study involved her forging a partnership with an elementary educator and co-teaching a science unit. Carlone and Webb were inspired by Abell's work. In both cases a hierarchy was formed in which the teachers perceived the researcher/scientist as more knowledgeable and powerful. Carlone and Webb analyzed the discussions between themselves and the team of teachers only to discover that the hierarchy existed from the moment the partnership started. By virtue of introducing themselves as researchers in a study the teachers were participating in, the teachers could never perceive them as equals in the classroom because their identity as researchers and university professors had already introduced a sense of inequality.

Hierarchy still remains a major issue involving collaboration between teachers and scientists. These "collaborations" have mostly been in the form of workshops and courses

(Stein, Smith & Silver, 1999) and have left teachers disempowered, with a sense that their knowledge is less valuable (Carlone & Webb, 2005). Carlone and Webb sought to establish a community of practice with elementary educators, yet what emerged from their experience was recognizing the deep-seated hierarchy that existed within these collaborations. A review of the literature seems to point out a need to address the disempowering hierarchy and to strengthen the community of practice. One of the methods aimed towards avoiding a hierarchy was having the participants identify their goals in the outset of the collaboration (Abell, 2000). These studies recognized the importance of identifying a common goal within the community (joint enterprise) but also recognizing that the partnership is beneficial toward meeting individual goals.

The research that has been done involving teachers and scientists seems to have two consistent characteristics and limitations: first, the teachers were sent outside of their school setting, and second, the teachers were mostly middle and high school educators. Moldwin et al. (2007) point out the shortage in teacher-scientist professional development on an elementary school level and stressed the need to develop science in earlier grades. Most research conducted involves middle school and high school educators, who receive much more science specific training for their jobs (Caton et. al, 2000). Secondly, all teachers were taken out of their place of practice, schools, and placed in the scientists' place of vocation; this gave the message that schools are not associated with real scientific practice.

Upon reviewing the literature, it was evident that there are major developments to be made in linking educational communities of practice with scientists. First, high school and junior high school teachers are more often the participants in the research. In addition, the research indicates that there is a lingering question of how materials covered in workshops were implemented at schools (Lumpe, 2007). Furthermore, with teachers being sent away to learn from scientists, there was an issue of hierarchy, which could lead to diminished confidence in teachers' ability to teach science and connect with the scientific community (Carlone & Webb, 2005). This study details the experience of an elementary educator's participation in a community of practice with a scientist as a means of developing an under researched method for professional development.

Theoretical Framework

I turn to two major theoretical frameworks as I construct an understanding of the teacher-scientist community and the development of the members within it. These theoretical frameworks include: Communities of Practice and Carlone and Johnson's (2007) Model of Science Identity. I have selected these perspectives as they complement one another and allow me to delve deeper into understanding the interactions between the research participants.

I recognize that the community forged within their study is a community of practice as the participants are coming together for a joint enterprise (Wenger, 1998). This framework allows me to construct an understanding of the participants from outsiders (non-participation) in a community into members (Lave & Wenger, 1991). I also recognize that boundary practices exist when two communities come together (Wenger, 1998), and this can result in the construction of a new community with a combined or newly shared repertoire. Lastly, I recognize that a successful community of practice is one in which all the members feel that they are both contributing and benefiting (Wenger et. al, 2002).

Carlone and Johnson (2007) constructed the Model of Science Identity in order to analyze the identity of women of color who perceived themselves as successful. They then identified three dimensions of science identity: competence, performance, and recognition. I used this theoretical framework to understand that the acquisition of skills and scientific knowledge will increase the teacher's competence and allow her to view herself as someone who is capable of teaching science. Within this study, I use this theory to frame the development of my participants and how they view themselves and each other as their community develops. The research question for this study is: (1)What are the characteristics of a teacher-scientist community of practice (i.e. shared repertoire)? (2) How does participation in the community of practice impact the members' perceptions of one another?

Methods

The Setting, the Teacher and the Scientist

Most past research in the professional development of teachers, both in the area of science and outside of it, has sent teachers out of the school (Stein, Smith, & Silver 1999). The focus was on content and how much teachers could bring back from participation in workshops and implement it within their classroom (Drayton & Falk, 2006). In order to avoid the notion that scientific knowledge is situated outside of school walls, this study was conducted in an elementary school. The school is a private school, which at the time of research served K-6 grade students.

The elementary school teacher, Alison (a pseudonym), was selected because of her expressed comfort with teaching. Alison has been teaching lower elementary pupils (grades K-3) for five years and volunteered for the study because she expressed a desire to develop herself professionally in an area that she expressed discomfort with: teaching science. Alison has a Master's degree in Curriculum and Teaching, but does not recall taking any science courses after high school. She expresses a passion for yoga and physical education, which she teaches in an afterschool program. Alison was selected based on the research criteria that the educator within the study feels confident in their overall pedagogy in order to get a sense that she is contributing the educator-scientist community of practice.

The scientist, Daniel (a pseudonym), was selected because of his expressed desire to develop himself professionally. This is an integral selection factor for the participating scientist, as the scientist must be entering the community seeking to gain something and not merely viewing the community as a growth opportunity for the teacher. This would establish a hierarchy and therefore one member would not feel that they are contributing equally to the community of practice. Daniel is a microbiologist at a university whose main work involves breeding microbes in order to gain an understanding of the phylogeny of species. Daniel also serves as an adjunct professor of science. He has been practicing science for over two decades. Daniel has presented in the researcher's class in previous years as an assistant to another scientist.

The teacher-scientist partnership was aimed at preparing a mini-unit (four lessons) for implementation in an afterschool science program for a mixed kindergarten and first grade living environment class named "Zoology." The partnership spanned one semester, whereas most models of professional development that link teachers and scientists have been short-term and with the intended goal of transferring knowledge (Drayton & Falk, 2006). The teacher and the scientist worked together to determine the lesson topics, plan the lessons, and teach them. The scientist explained scientific content and the teacher used her pedagogical strengths to identify essential ideas for the unit in order to keep the goals for the students consistent. Creating a new unit, as opposed to teaching a pre-existing unit, allowed their new community to develop its own repertoire and practice (Wenger, 1998).

Researcher Role

As an elementary science teacher, I saw myself as the link between the two communities of practice. I took on an observer role, and let the participation between Alison and Daniel develop naturally. Carlone and Webb's (2005) experience shaped my perceived role in this research. As previously discussed, avoiding a hierarchy is key to the success of this professional development model. I planned to only step in only if I felt that there was a hierarchy developing or there was difficulty communicating. I asked questions to guide the participants in examining how they were meeting the goals they set for themselves at the beginning of the study. I felt that my role as observer allowed the participants to forge their own practice (Wenger, 1998) and therefore my own practices were not imposed on them.

Data Sources

The data consisted of various sources designed to capture the experience of the participants at various points throughout the process. These data sources are described in the Table 3:

Table 3: Descriptions of Data Sources

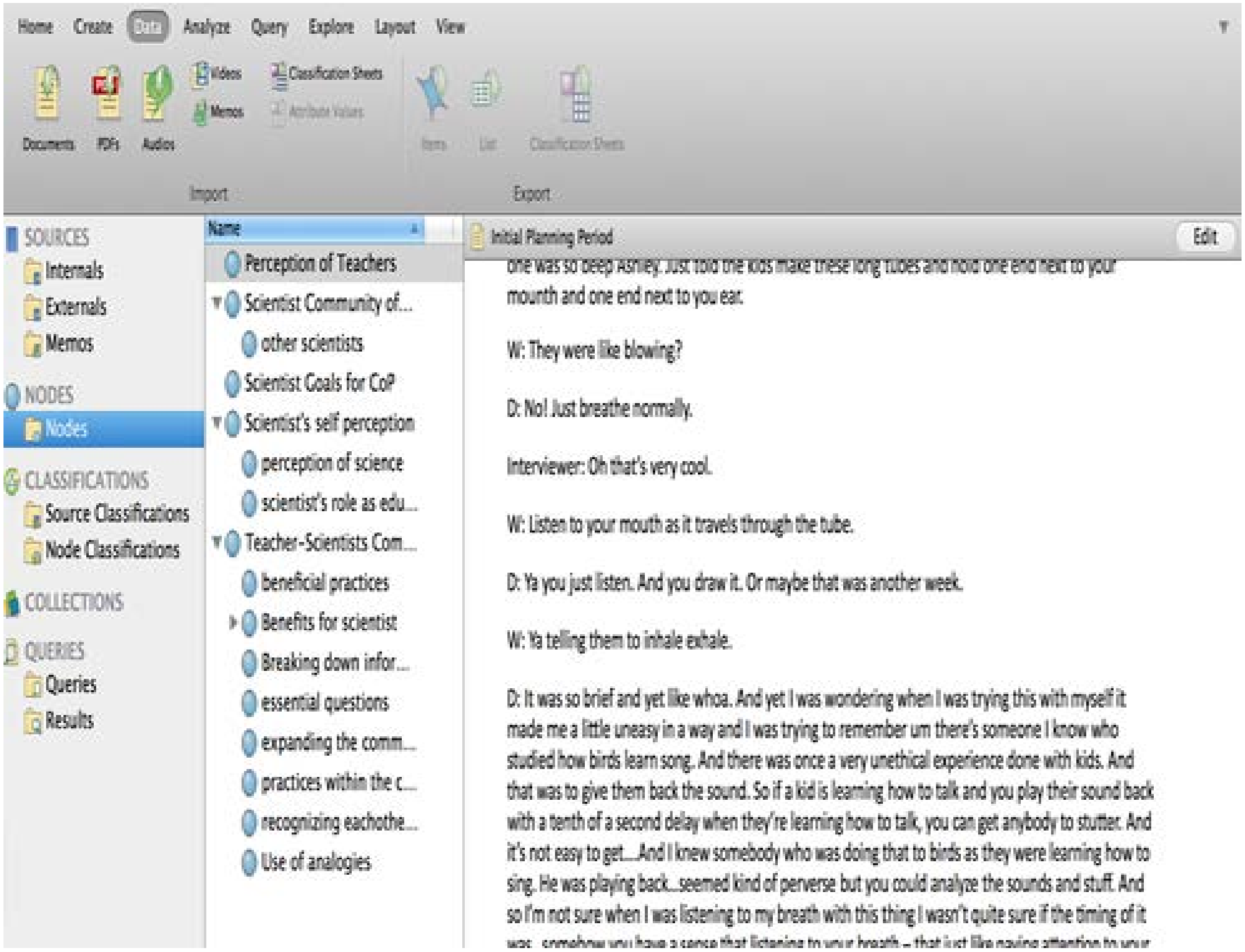
Data Source	Description
Entrance Interview (Audio)	A 30-60 minute interview done with each participant independently. The entrance interview obtained information about the participants' perception of each other and their profession. During the entrance interviews, each participant identified goals; these goals were compiled and shared with the other member.
Initial Planning Period (Audio)	The initial planning period brought the scientist and the teacher together to explore ideas for the mini-unit.
Post Lesson Planning Sessions (3)	The teacher and the scientist met after the first three lessons for 30 minutes to reflect on the lesson taught and to plan upcoming lessons. This was an opportunity for content information to be explored as well the exchange of pedagogical strategies.

Notes during Lessons	Notes taken during the lessons were used to generate questions for the online journal entries.
Online Journal Entries	Participants answered specific reflection questions posed by the researcher after each lesson. They also included any other information they felt relevant. The participants did not view each other's journals.
Email Correspondence	Participants communicated via email prior to each lesson to finalize or develop ideas. The teacher emailed the final lesson plan in the format she saw fit.
Exit Interview (Audio)	Participants were interviewed a final time in order to identify any changes in perception or development since the entrance interview. In order to do this, the majority of the entrance interview questions were repeated. Other questions were added based on what was observed during the partnership.

Data Analysis

In order to track development of the community throughout their participation in the study, data was collected and analyzed throughout the process. This allowed for clarifying questions to be asked within journal reflections and during lesson planning conversations. All audio records (entrance interviews, planning meetings, and exit interviews) were transcribed and coded using a Computer Assisted Qualitative Data Analysis Software (CAQDAS) called NVivo. NVivo allows for the creation of nodes as data, and is read and interpreted by the researcher in order to group common ideas together across various data sources. The nodes, were initially comprised of categories stemming from the research questions, but subcategories and new nodes were added whenever the participants presented repeating ideas. Nodes gathering data across multiple sources allowed for the triangulation of data (Merriam, 2009) in order to increase validity and rigor (Denzin, 1970). Figure 1 illustrates a screen capture of nodes in NVIvo.

Figure 2: Screen capture of Nodes in NVivo showing the text to be coded in the right-hand panel, and the relevant code names or the nodes assigned to the text in the left-hand panel.



Findings

Basic structures previously described under methodology were set in place in order to establish a qualitative study that is ethical, valid, and reliable. However, the participants within the study had to be given the freedom and the flexibility to establish their own practice within their emerging community to determine what best worked for the nature of their interaction. The findings present naturally occurring shared repertoire within the teacher-scientist community. Coded data across multiple sources from both participants indicated that they felt that these practices were conducive to the functionality and development of their community. Below are the four emergent practices from the analysis of the multiple data sources.

Pre-Planning Visit

In the original plan for the research, Alison and Daniel were intended to begin their participation at the first planning meeting, where they would learn more about each other and begin forming the lessons for their afterschool unit. However, a few weeks prior to the initial planning period, Daniel requested that he visit Alison as she teaches so that he can observe her in her teaching element. This pre-planning visit, which was completely initiated by the participant of the study, set a strong foundation for the pair. Daniel observed Alison teaching yoga in the park as part of an afterschool program:

> I saw Alison during this beautiful yoga class and teaching the children about breath and air in these subtle ways … blowing on the cloth and waving on the cloth and drawing their breath. That was where air came from and that was were breath came from, and it struck me as a beautiful scientific investigation…How would you make Alison comfortable with science, where's the bridge of her comfort? Well she did this; she's certainly there. (Daniel, Exit Interview)

It was during this visit that Daniel witnessed Alison teaching breathing methods and air's ability to move things. Daniel saw these interactions as science, as Alison asked the students various ways to keep the cloth elevated while integrating ideas of human respiration. To him, she was already practicing science and he felt that it was his role to help her see her strength.

From his pre-planning visit, Daniel not only developed an understanding of Alison's interests and strengths, but also began to solidify his own goals. He saw Alison's skill at formulating questions with the students both as a direct part of the lesson and as part of their everyday interactions:

> … to ask questions as a normal part of kids' lives. So when somebody would get up and walk kind of through a group, to get to where they were going, she asked the question, how could I get to where I'm going or would the best way to get to where I'm going be stepping all over the people? How can I do this? Ask yourself the question, what's happening? (Daniel, Entrance Interview)

Daniel then continues on to define what he thinks an educator is by stating: "An educator, to me, the most purest thing, is somebody who's deep into something and flat out trying to find out" (Daniel, Entrance Interview). The formulation of questions became a major goal for Daniel in this research. He saw Alison's pedagogical strength as someone who helped people formulate questions and stated his goals for the partnership accordingly:

> I am curious about the cultivation of scientific taste and the formulation of good questions. The view that I want to explore is that the curiosity can be cultivated and refined-- to directly cultivate questions, and taste for good questions. A related question is if, and how, to cultivate imagination, empathy and analogy as scientific method (i.e., to use them in the framing of scientific questions and interpretation). I am curious of the methods that can be implemented to communicate these ideas and questions to vast audiences. (Daniel, Entrance Interview)

Daniel felt that working in a setting with children would be key to helping him attain this goal because of his perception that the scientific field had reversed the process and complicated what is naturally practiced by children. He explained:

> I feel that asking good questions and framing good questions is usually thought of in scientific work as kind of the culmination of education. Well, children of course ask great questions. Then to actually be a scientist you have to have many years where you just learn facts in some kind of rote way. Then you learn how to do an experiment in

> some kind of rote way and then you do a project, various labs given to you, collect new numbers in a kind of rote way. Eventually when it's all done at the end of that, you'll acquire scientific taste about what questions to ask (laughs) and that strikes me as very backwards. (Daniel, Exit interview)

The pre-observation visit helped Daniel observe Alison for a few hours practicing within her teaching community-- her elementary classroom. Should Alison have visited Daniel in his laboratory? While this would seem like a logical balance to the formation of their community, Alison did not request to go visit Daniel in his place of work and therefore I did not recommend it as the researcher. Once again, I did not want to interfere so that community practice could develop from within.

Topic of Interest

The benefits of the pre-planning visit remained evident in the first planning period as Daniel and Alison brainstormed ideas for the lesson. Once again, the only guidelines they were given is that the lessons were to be taught as part of a zoology study in an afterschool program for K-1 students. Alison was at first concerned with the open-endedness of the unit. She asked what the students should study specifically, but the same limitlessness of science that once made her uncomfortable became what put her mind at ease: "You told me not to worry about that and just go with, and just let our conversations guide our lessons and I became a little more relaxed" (Alison, Entrance Interview).

Alison's work on breathing during her yoga class became fundamental in establishing the unit idea. Embedded within the lessons were her strengths in developing movement exercises. She designed movement games in which the students role-played the animal being studied and the movement of air. Alison was able to use her own interest as a launching point for teaching science. During the initial planning session, Alison and Daniel discussed the properties of air and how it would relate to animals. Their conversation was fluid; they went back and forth narrowing down ideas. Naturally Alison began to explain teaching methods, such as establishing essential questions to help guide a unit of study. The transcribed conversation below is the first time Alison describes essential questions to Daniel.

Alison: So I'm hearing the word natural and what's instinct. It might be kind of interesting to work with the breath and observe what's natural for us or our natural breath and observe it first in ourselves. Then explore the way the animals breathe differently. Marine animals versus land animals.

Researcher: Can you explain the sequencing that you just described?

Alison: So when you're planning a unit or planning a curriculum you have this overarching theme. And you want to step back and think about how you're going to approach it and how it's going to be accessible. So all these breath activities are all the activities of the lesson. But what are we trying to discover? What are we trying to figure out? I'm thinking about essential questions. What do we want them to know? What do we want them to explore? What are the end points and what are all the pieces to get there?

Meanwhile Daniel was helping Alison by providing content for her so that she could better understand the topic. Their creation of a unit not only allowed for an exchange of information, but also a formation of the questions, something that Daniel hoped would happen. Furthermore, Daniel indicated in various data sources that as he explained scientific concepts to Alison, he himself was revisiting the concepts in a new light and reshaping his own understanding of them.

Daniel:	Well like the olfactory bulb in a human brain is certainly bigger than the olfactory bulb in a rat brain. But proportionally to the reset of the brain it's a lot smaller. And that's kind of what I'm wondering. So…I'm not…it's not clear to mean that we actually do smell less than a rabbit or a rat. I don't know that. I suspect that consciously that's very true. But I don't know where it's going if you don't know it…I don't know where that information is going.
Alison:	How would we be able to know? You won't ever be able to know. Right?
Daniel:	Unless you experience it through the rabbit. Yeah, it wouldn't be your experience. (Initial Planning period interview)

It was decided by the end of the initial planning period that Alison and Daniel would teach a series of lessons with the theme: Air as Messenger. The lessons would help the children form an understanding that air is necessary for the transfer of sounds and smells. They planned on bringing in animals throughout the unit so that the children could observe and test the animals' sense of smell and ability to detect sounds. Although this was not directly linked to what Daniel observed Alison teaching in the park on his pre-planning visit, it was their discussion of the movement of air that launched the conversation. Several lessons would include yoga activities that Alison adjusted to teach scientific concepts (see Appendix

C). To Alison, the selection of the topic was a moment of validation of her contributions to the community:

> It feels amazing to have a scientist recognize the value of something that I teach every day, and something that is near and dear to my own practice. I think that it was also respectful on his part to discuss something that I am interested in, especially because he knows that I have a certain discomfort level with teaching science. (Alison, Reflection Journal)

Developing the topic themselves gave them a sense of ownership and a joint enterprise to bring their communities together. This is what Wenger (1998) refers to as a boundary encounter. Teaching a pre-designed unit would not have had the same impact, as it was the process of creating something new between them that allowed them to pour their own thoughts and ideas into the unit. Alison expressed this by stating:

> I enjoyed the planning session because it really started out wide-open and we were able to narrow our focus by the end. I think I expected to go in and follow up on some lessons you [the researcher] had already taught, but the journey we took through our conversations and new ideas popping up was great. You start with an idea or concept, and it grows and changes based on the questions at hand and where we want to take the kids. (Alison, Reflection Journal)

Daniel had a similar sentiment as he saw the unit they created as a truly unique product of their collaboration:

> A very important fact- a central fact- is that Alison and I together created something that did not exist before and would not have otherwise existed. I now think of Alison as a creative collaborator. This is an accurate statement of reality. It is not so much that my perception of her changed but our reality changed. We created something

together. You know, one of the things in a community of scholars is, anybody can question, anybody can create. The community as a whole creates things that nobody could have on their own. Through this I have high regard, deep appreciation, joy, and hope for what more can be done. (Daniel, Email Correspondence)

Expanding the Community

A heterogeneous community is one of the features identified by Wenger (1998) of a healthy community of practice. The selection of the participants reflected this goal as this teacher-scientist community brought together two individuals from two different professional communities with different professional skills. Approximately halfway through the study Alison and Daniel began expanding their community of practice by inviting others and drawing on their expertise. Once again, it must be emphasized that this is a practice that was not initiated by the researcher, but one that naturally manifested itself. Examples of the other members who were invited to participate are presented at a later point below.

Analysis of Daniel's data indicated that he was always interested in the work of members within his scientific community of practice. Data sources indicate that he made roughly a dozen references to other scientists ranging from personal acquaintances to famous scientists in the field. When asked how he came to be a scientist, Daniel explained, "I followed the path of following the nicest, smartest people and studied what they studied" (Daniel, Entrance Interview). For Daniel, there was always a connection between his practice and the members within it.

Alison made reference to four teachers she worked with in the past that helped her develop in the areas of mathematics and literacy. Alison expressed that her Master's degree did not prepare her to teach science. Alison expressed that while her degree was focused on literacy she was not prepared to teach early reading strategies, but that was not an issue for her because she had the support of her colleagues: "We are always bouncing ideas off each other. Constantly learning from other teachers" (Alison, Entrance Interview). Yet with science she did not identify a person to go to early on in her career.

The first person Alison and Daniel invited into their community was a teacher named Heather (a pseudonym). Heather has a pet rabbit, and Daniel and Alison wanted the children to observe how the rabbit smells and hears. Heather was not merely invited in to handle the rabbit. Rather, her expertise on the animal as a pet owner was drawn upon and discussed in the lesson:

> I spoke with her about the types of foods he likes and gravitates towards and what she noticed about his nose and if the twitching changed in any way based on different experiences. I asked her about his sense of hearing and she told me about her research on floppy ears based on her observations of him not seeming to hear well. This led me to a bit of floppy-eared research of my own! During the second lesson, I decided it would be a good idea to interview Heather in front of the kids, so they could form their own conclusions about muffled hearing. (Alison, Reflection Journal)

Another fellow teacher, Lindy (a pseudonym), was also called upon to bring her dog, Benji, in for observation. The dog was given challenges to sniff out treats:

> Lindy and I had a couple of conversations prior to the Benji lessons about his sense of smell and hearing. She gave me some anecdotes about the dog's interaction with the dog whistler app, and how he turned his head and perked his ears when she activated the whistler. She told me how he barks at the door minutes before anyone opens it, which is similar to what I read online on various dog center sites. Lindy also had Benji groomed before each lesson, so that he could look his best! (grooming a long-haired

> dog also helps keep the hair out of the eyes, nose, etc. which was also vital to our lesson). During the second Benji lesson, we also interviewed Lindy, to get a sense of Benji and what noises capture his attention. We were also trying to figure out if he can hear/sense sounds better than us, which is why we experimented with the dog whistle and talked about the barking at delivery men (Alison, Reflection Journal)

In both situations, Alison was calling on her fellow teachers for scientific information on animal behavior.

Alison considered both Heather and Lindy as part of her teaching community, but were both invited into the teacher- scientist community because of the knowledge she learned they possessed.

> We wanted them to become members of the community, because they had something to give, something to share, because they had resources that we wanted. Like we wanted to tap into Annie's technology and we wanted to tap into Heather's bunny, and so we invited them. (Alison, Exit interview**)**

Previously, Alison could not identify a specific person to go to for scientific information, but in through these interactions she was beginning to see that scientific knowledge was dispersed throughout the members of her scientific community.

Similarly, Daniel sought out the help of an acquaintance who works as a professor of music composition. Daniel also reached out to the school's technology coordinator, Annie (a pseudonym). He wanted her expertise on setting up a bass speaker to show musical vibrations.

Roles in Teaching Lessons

There was a lot of thought and preparation that went into the planning of the individual lessons. While the "what" and the "how" were discussed it was never determined the roles that each participant would play in teaching the lessons. The lessons could have been completely led by Alison with Daniel as an observer, or they could have co-taught, taking turns speaking with the children. Daniel reflected on this stating, "We had discussed these things, but we didn't discuss how we would really do it in the class. That just evolved" (Daniel, Exit interview). The possibilities were left open in order to determine what the members in the community would select upon once the written lesson became a lived experience.

When it came time to teach the lesson, Alison took the lead, teaching the main portion of the lessons with Daniel sitting on the rug with her and the children, but off to the side. Whenever it came time for the children to work independently, Daniel would work with small groups or walk around the room and talk with students. Alison also engaged with the students during as they did the hands-on portion of the lesson. For Alison, this was a normal part of her pedagogical practice as she would talk with the students, gauge their understanding and try to scaffold information. Daniel engaged with the students and had the opportunity to hear them ask questions as they experimented. Daniel wrote of the moments he worked with the students as they mixed different chemical to produce various smells in his reflection journal: "One of my favorite things in a laboratory with other people is how cute people's faces are when they are doing experiments they care about." He was seeing the same joy for experimentation in the kindergarteners and first graders as he saw with his scientist colleagues as they conducted their work.

Then during a class discussion on smells, Daniel positioned himself closer to Alison on the rug and started using Ping-Pong balls to act out what she was discussing about smell molecules. He never spoke with the children, or interrupted Alison. In fact, she realized what he was doing and slowed down her speech so that he had time to interpret and so that the students could take it all in:

> I am trying to do this with Alison but instead of sitting still, I am acting out what my attention is doing in my mind. When Alison is speaking I think of myself a little bit like an interpreter for the deaf using full-body and prop sign language to communicate to another parallel sensibility. (Daniel, Reflection Journal)

During the planning session, Alison expressed concern that the demonstration might have been too abstract for the children. They worked together to determine how they could make more demonstrations. While the students were not involved in planning the lesson, they reshaped the direction of each lesson, and eventually the unit, with their questions, their interests and even their lack of understanding. It was during the teaching of the lessons that Daniel and Alison were able to determine how effective and engaging their lesson ideas were for the children. In the case of the Ping-Pongs, the children were confused by the demonstration and so they needed to reshape the next lesson for clarity. They decided that for the next lesson they would set up smelling and mixing stations. During the lesson a few students were drawn to a molecular model kit that Daniel had brought in to discuss smell molecules with Alison. He has used an analogy of letter forming words to discuss molecular arrangement. They did not plan to originally share the models or this analogy with the students, it was just a shared repertoire they established between the two of them. The other children noticed that the molecule set showed differences in sizes and wondered if size had something to do with different smells escaping different materials.

Daniel continued this practice in the following three lessons. He allowed Alison to take the lead on teaching the children, while assisted her by providing visual aids. Alison wrote of these moments in her reflective journal:

> Daniel and I seemed to be working in perfect conjunction at this point, as everything came to fruition. These are the moments in teaching that a teacher lives for: when connections are made based on our shared experiences, prior knowledge, and group discussions that truly showcase a child's understanding. (Alison, Reflection Journal)

The teaching-demonstration model became the repertoire for teaching the lessons in their community. It was not just a practice worked to facilitate the lesson; it was reflective of something more. Daniel never stepped in or asked to teach any part of the lesson. Alison never asked him to manage or to explain information directly to the students. The students' reactions and comments guided the lesson within it, and shaped upcoming lessons. Where the Ping Pong ball demonstration was confusing for the students. Daniel recalls the reaction of the students when they used cornstarch on a bass speaker with a domino set to illustrate the movement of sounds:

> Alison was talking about bumping molecules, the speaker was bumping cornstarch-water-food coloring to the music and I was setting up rows of dominoes that kids were playfully knocking over. If that wasn't a sweet scene I don't know what is. This sort of thing was going on for a few minutes when a student exclaimed, "Oh, I know why he's doing this!" Alison may have asked what she saw just then and the student said the dominoes were an analogy to molecules in the air knocking into each other to carry the sound. I think some of the kids as well as adults did a double take at the child's insight and articulate expression. (Daniel's Reflection Journal)

They lived out the lesson they designed and their roles just fell into place, with Alison emerging as main educator in the room. The purpose of their collaboration was not to turn Daniel into a teacher. Daniel and Alison recognized that it was never his goal for their community of practice. Furthermore, perhaps it belittles the teaching profession when outsiders, such as visiting scientists or graduate students, come in and assume they could teach the lessons as if they were trained educators, if they are not. Daniel recognized Alison's mastery of teaching and his respect for it was essential:

> I could admire her especially dealing with a group… level of excitement, keeping the excitement there at the same time keeping focus, keeping people respectful of each other and of the animal and of the material. That is just amazing--just amazing. Yeah I mean it's obviously really exhausting work, watching everybody, you know, it's like having this pot that's kind of like simmering just below explosion. And she keeps it simmering…Amazing to me and I clearly couldn't have done that. (Daniel, Exit Interview)

Daniel and Alison never considered themselves members of each other's community (scientific and teaching communities). They allowed each other to do what they knew how to do best-- what they dedicated their professional lives to learning. They put these skills together to present children a glimpse of the inner workings of the invisible air that surrounds them.

Discussion and Implications

This study details the experience of an elementary educator's participation in a community of practice. The four practices that have manifested themselves in the teacher-scientist community (described previously and summarized in Figure 4) have one thing in common. All of these practices developed because the study's participants had freedom to do so. The framework that I have established as the researcher, based on past studies, only provides a general framework for community of practice, but Daniel and Alison still had a lot of shared repertoire to establish on their own.

Table 4: Established and Emerging Practices of the Community

Researcher Established Practices	Community Generated Practices
• Establishing and sharing goals • Holding an initial planning session • Facilitating three post-lesson meetings • Maintaining email correspondence to finalize lessons	• Participating in a pre-planning visit • Creating a self-generated topic stemming from group interest • Expanding community membership • Negotiating roles within the classroom

The pre-planning visit not only allowed Daniel to solidify his goals but it also helped him identify a topic that might ease Alison's mind about teaching science because she was already interested in it. When he told her that he saw her yoga and movement activities as a scientific investigation of air, she started to reconstruct what it meant to teach science. An analysis of this experience through Carlone and Johnson's (2007) Model of Science Identity demonstrates why this could have been a turning point for Alison. According to Carlone and Johnson, one of three main factors of developing a strong science identity, besides confidence in scientific knowledge and scientific practices, is to be perceived by others as a "scientific person." Daniel established early on in the formation of their community that he viewed Alison's work in physical education as scientific. Having this acknowledgement legitimized Alison's practice in her perspective. It was no longer about her learning enough science to, one day, be able to develop a stronger sense as a teacher who can teach science. Rather, Daniel's recognition established that she was already skilled and knowledgeable enough to be able to do so.

Using skills she was already comfortable with allowed Alison to teach science with limited scientific pedagogical content knowledge (PCK) (Shulman, 1986), which is the knowledge needed to teach a specific subject. Bell, Veal and Tippins (1998) identified a hierarchy, which arranged PCK into categories including a broad base of science, discipline specific knowledge, and a more granular PCK for individual topics. They concluded that elementary educators generally do not have a chance to develop anything beyond a broad science PCK, as the other forms of PCK are developed through repeated experiences.

By expanding the community, Alison and Daniel were able to bring in expertise beyond their own. This study does have its limitations because it was only conducted with one scientist and one teacher. Two people still qualify as a community of practice and more participants does not necessary mean a healthier community. However, more individuals within the community brought an expanded skill set and knowledge. The participation of the other teachers and the musical composer brought in by Alison and Daniel is just a glimpse into what a teacher-scientist community of practice would look like with expanded membership.

Lastly, the negotiation of roles in the classroom was fundamental if their lessons were to be successfully carried out. In this particular case, the teacher was responsible for most of the teaching of the lesson. In fact, the presence of the scientist was never really essential for the teaching of the lesson. One could argue that this is the ideal situation as the hope is for the teacher to be able to teach the lessons independently and develop her own science PCK that does not involve the presence of a scientist in the room, as that is not a sustainable practice. Alison maintained her role as teacher and Daniel took on the role as observer/assistant. He posed questions by silently setting up models and demonstrations while Alison was speaking to the whole group. He felt that these demonstrations supplemented instruction and triggered curiosity. David rarely addressed the whole class verbally. He mostly spoke directly to the students during small group work.

The participants' roles during the teaching of the lessons demonstrate recognition of each other's unique skills. Studies concerned with teacher identity and avoiding a hierarchy focused on submerging the scientists within the school for the purpose of team teaching with the educator (Abell, 2000; Halversen & Tran, 2010). Carlone and Webb's (2005) study aimed at preventing the formation of hierarchy by proceeding with a teacher-researcher partnership as if they were all equal. Yet it was this attempt to avoid hierarchy that actually caused it. The researchers and the teachers had different skills set and different priorities. The teachers wanted to deal with issues on a case-by-case basis, while the researchers wanted to carry out the practice of their own community and establish patterns and make blanket rules to understand certain behaviors. Equality within a community does not mean pretending that everybody is equal. Rather, hierarchy is avoided when everybody knows how they contribute to the functionality of the community using their own different skill set. Daniel and Alison were crossing boundaries (Wenger, 1998) into each other's communities and so there is realignment in how the skills and knowledge contributes to this new community. They recognize that they are now dealing with individuals with completely different types of knowledge and skill set as part of their partnership (Anagnostopoulos, Brass, Subedi, 2007). It is this respect for the work of the other where a power struggle between Alison and Daniel is avoided.

Conclusion

In this study, a teacher and a scientist have come together to create something that they would not have otherwise been able to create on their own. They set goals early on and they were each aware of the other's goals and what they each contributed to the community of practice. I set practices for the community based on limited research involving teacher-scientist community of practice, as well as broad research involving healthy community of practice guidelines. The autonomy and flexibility provided in this study have allowed participants to create their own community repertoire as they worked on a joint enterprise and for the course of their partnership brought together two communities who generally do not interact with one another. Shared repertoire created within their community can be used to inform the formation of other boundary encounters between elementary teachers and scientists.

Chapter V

THE USE OF ANALOGIES AS A MEANS OF COMMUNICATION IN A TEACHER-SCIENTIST COMMUNITY OF PRACTICE

Abstract

This study examines the use of analogies as a means of communication of scientific content. The analogies were used as communicative tool in a community of practice involving an elementary educator and a microbiologist. The community of practice model, as proposed by Wenger (1998), was used to order to understand the analogies as an emerging shared repertoire between the practices. Findings show that analogies were successful as a tool for teaching scientific content knowledge and that the teacher in the community willingly used them to inform her own pedagogy.

Keywords: communities of practices, elementary education, professional development of scientists, scientific analogies

Introduction

A community of practice is a group of individuals who come together surrounding a common goal or interest (Lave & Wenger, 1991). Each community develops its own rituals, practices and discourse known as a shared repertoire (Wenger, 1998). These features are what define the community to the members within and to those outside of it. This study examines the formation of a shared repertoire when a teacher and a scientist were brought together for the purpose of designing a professional development model that would be beneficial for *both* of their respective communities. For example, elementary teachers and scientists are two communities that rarely interact, despite the fact that teachers are meant to instill authentic scientific practices. For this reason, partnerships between educators and scientists are encouraged as a means of increasing public science literacy (Halversen & Tran 2010). However, most studies have not involved elementary educators, and there is an interested call to learn more and develop professional development specifically for elementary educators (Moldwin et al. 2007).

When two communities of practice meet they are crossing boundaries into each other's communities, but over time they can create their own new community. They could come together for a common goal, or *joint enterprise* (Wenger, 1998). A joint enterprise is a product that results from the members of the community coming together and negotiating surrounding a common goal. As they work on a common goal, members could introduce their practices from their individual community through a process called *brokering*, which in the introduction and negotiation of practice across communities (Wenger, 1998). The coming together of two communities can be a powerful and eye-opening learning experience if--and only if--the community is diverse enough to allow for member contribution as well as learning. Wenger explains:

> Crossing boundaries between practices exposes our experience to different forms of engagement, different enterprises with different definitions of what matters, and different repertoires- where even elements that have the same form (e.g., the same words or artifacts) belong to different histories. By creating a tension between experience and competence, crossing boundaries is a process by which learning is potentially enhanced… (p. 140)

This study details an emerging practice that was developed as an elementary educator and scientist collaborated and negotiated practices during the teaching in an afterschool K-1 science program.   The use of analogy became a prominent method of communication from scientist to teacher, which became a part of the teacher's developing science pedagogical knowledge (Shulman, 1986). The main focus of this research study is to explore some of the ways that the collaborating scientist developed his particular view of how his scientific knowledge could be adapted to the unique opportunities of the elementary classroom learning environment. This particularly focused on the use of analogies.

Literature Review

Linking the educational and scientific community is not a novel idea. It has become an increasingly implemented practice ever since the National Science Board's call for scientists to get involved in educational reform (Colwell & Kelly, 1999) and the National Research Council (1996) proposing that scientists provide professional development programs for teachers. While it may not be a new idea, is still one that is underdeveloped and under researched, especially when it comes to understanding the scientist's benefits (Andrews, Weaver, Hanley, Shamatha, & Melton, 2005), and with limited understanding of how these partnerships specifically benefit elementary educators (Moldwin et al. 2007).   The links between these two communities – elementary education and science/scientists-- have been in the form of community outreach efforts from scientists or science professors, which the majority of the time was giving presentations in workshops (Andrews et al., 2005; Stein, Smith & Silver, 1999).

One of the prominent issues with the workshop or presentation model is that the educators emerge from the experience feeling disempowered with a sense that their knowledge is less valuable (Carlone & Webb, 2005).   One of the features of a healthy community of practice is that all members feel that they have something to contribute

(Wenger, 1998). Therefore, identifying goals early on in a community and communicating those goals to all members is one of the key preventative measures for preventing the formation of a hierarchy (Abell, 2000). This practice allows members within the community to proceed with the notion that they have unique skills that could benefit other members and that their community is a conglomeration of those skills. This also draws attention to the need for a heterogeneous community with a diverse skill set so that individuals are not only gaining but also contributing (Wenger, 1998).

Scientists' Communication to the Public

For purposes of this paper, I will focus the literature review predominately on the benefits for the scientist, because the findings of this research study focus on a communication practice developed by the scientist, which aligned with his goals to explore methods of questioning and communication. Similarly, in a study done by Andrews et al. (2005) improving communication was one of the top three factors that motivated scientist participation in outreach programs. The other two included a sense of responsibility to promote scientific literacy and sheer enjoyment.

The need for improved scientist communication skills is necessary on multiple levels in our society and reaches beyond the classroom. Closing the gap between the scientific community and the non-scientific community is viewed as essential for a democratic and scientifically literate society (Andrews et. al., 2005; Bensaude-Vincent, 2001). The public is getting most of its scientific information from the media, which compounds the issue as journalists do not have enough of an understanding of science to communicate the information accurately (Chappell & Hartz, 1998). Therefore, there is a need for scientists to be able to communicate their work directly to the public to limit the formation of misconceptions and oversimplification of findings.

Scientists are aware of the need to improve communication. An overwhelming majority of scientists surveyed expressed an interest in improving their communication skills with the non-scientific community (Hartz & Chappell, 1997). The former head of the National Science Foundation, Neal Lane, stated, “With the exception of a few people…[w]e don’t know how to communicate to the public” (Hartz & Chappell, 1997, p. 38). Yet an attempt at communication does not mean that communication will be successful. Some even argue that since there is a large number within the general population who are scientifically illiterate (Miller, 1991), we should not focus on *how* scientists should communicate to the public, but determine *what* the public needs to know (Weindgold, 2001). Furthermore, targeting the majority of the adult public could be a waste of time; scientific illiteracy stems from a lack of proper science education in schools; and, perhaps, that is where it should be targeted (Eisenhart, Finkel, Marion, 1996). Therefore, the “solution” should be battled on two fronts: nurturing a scientifically literate society through improvement in education (including teacher education and teacher professional development) and providing opportunities and professional development for scientists to improve their communication skills.

Use of Analogies

Piaget (1929) offers a strong foundation for how we frame new information and learn. His widely accepted work on assimilation and accommodation of new information has led to a vast number of studies of learning and the development of cognitive schemas. Most researchers now agree that individuals are not blank slates and thus there must always be recognition of the cognitive interactions between what is being taught and preexisting concepts and ideas (Ausubel, 1968). The mind is then viewed not as a pile of information, but rather as an intricately organized and interconnected system (Anderson, 2009). While these interconnections can lead to the formation of misconceptions (Gomez-Zwiep, 2008), they can also be helpful when introducing new and complex concepts.

The use of analogies has been identified as an important determinant of a learner's accommodation of new ideas (Posner, Strike, Hewson, & Gertzog, 1982). However, improper use of analogies can also contribute to student misconceptions or misunderstandings of scientific phenomena unless carefully organized and clearly related to the scientific phenomenon to be learned (Guerra-Ramos, 2010). An analogy is commonly recognized as consisting of a source and a target. The source is generally something very familiar and is therefore used as a launching point to understanding a more complex or less familiar concept known as the target (Holyoak & Thagard, 1997). While no analogy is perfect, research indicates that they are effective tools, at the very least, for initial explanations or references, but not as a method to bring about conceptual change (Chi, 1992; Dagher, 1994).

In terms of science education, recent studies have examined the use of analogies when teaching abstract or complex scientific topics. For example, Chiu and Lin (2003) used analogies to teach elementary students about electric circuits. Their study not only found increased understanding among students, but also actual breakdown of misconceptions that the students had regarding electricity. Their findings were in agreement with Brown and Clements's (1989) support for the use of analogies to not only introduce new concepts but to also use as a tool for deconstructing misconceptions. Other studies, varying in approaches and theoretical frameworks, all concluded that the use of analogies was a powerful pedagogical tool across various scientific topics (Chiu & Lin, 2005; Baker & Lawson, 2001; Duit, 1991; Mayo, 2001). While the pedagogical benefits for using analogies are evident in the research, it should not be concluded that the cognitive and learning benefits of analogies are exclusive to novices. Rather, analogies are a tool used by practicing scientists (Chiu & Lin, 2005). Findings from the current research study demonstrates how the scientist used them as a form of communication to the teacher, who fine-tuned them as a shared repertoire of their emerging community. This contributes towards addressing the research questions: (1) What practices are mutually beneficial in an elementary educator- scientist community of practice as a means of professional development? (2) How can practices be brokered to overcome boundaries between the education and scientific community?

Methods

It was essential to provide my research participants with sufficient autonomy to allow them to establish their own practices without interference from the researcher. Therefore, I felt that ethnography as the prominent methodology was fitting. The major defining feature of ethnography is its focus on understanding a culture (Merriam, 1998). It provided a means to more fully document and interpret the community formed between the teacher and the scientist as an emerging culture. As part of this method, I immersed myself in the culture without interfering with its development. I only interjected to facilitate research related questions and to allow participants to communicate goals to one another. I studied their interactions and the progression of their relationship. Names of the participants are pseudonyms.

Participants and Goals

Alison is a lower elementary teacher who has been teaching for five years. She holds a Master's degree in elementary education with a specialty in literacy and certificate in gifted education. She teaches at a K-8 private school, in which she is a generalist and co-teaches kindergarten. Alison also teaches yoga and physical education as part of the afterschool program. Alison qualified for this research as she perceived herself as a skilled educator and was confident in her overall pedagogical skills. Her goal for this research was to gain confidence in the teaching of science by gaining content knowledge and more experience with teaching elementary science.

Daniel is a microbiologist who has been in the field for over 30 years. He works predominantly in a laboratory, but teaches undergraduate and graduate-level science courses. Daniel has published more than two dozen articles in scientific journals. Almost all of his publications have been collaborative efforts, as Daniel highly values fellow scientists and often discusses their work as part of this study. Daniel entered this research with the goal of gaining pedagogical methods that would allow him to promote the cultivation of questions when he teaches. Daniel also wanted to determine "how ideas and questions can be communicated to vast audiences" (Daniel, Entrance interview), thus relating back to interest in community science research to the general public.

The Setting

The teacher and the scientist came together at the private elementary school in which she is employed. The lessons designed were taught in an afterschool science program entitled Zoology, for a mixed kindergarten and first-grade class for the first semester of the school's academic calendar, September- December. Several instructors taught the course on a rotational basis, which included myself, part-time science teachers, and guest speakers who were experts in a scientific field. Therefore, the students were accustomed to working with a variety of teachers. The course focused on various lessons that all came together around the study of animals.

Data Sources and Analysis

A variety of sources were used in order to continuously check-in with participants throughout the research and learning process, both individually and jointly. This included an entrance interview, which was approximately 30-60 minutes in length for each participant. An initial planning period brought the participants together to start brainstorming the unit and create a skeletal outline. The participants met three more times, after each of the first three lessons, for further planning and reflection periods. Their email communications were also compiled and used as data. It should also be noted that the scientist requested to observe the teacher in her classroom prior to their partnership in the study, but I was not present. As the researcher, I took notes during the lessons, and these were used to generate questions for the participants to respond to in their individual electronic journals. Finally, they were once again interviewed as part of an exit interview at the conclusion of the study. All interviews and planning sessions were audio recorded and transcribed. Figure 3 provides a sequence of the events of the study to demonstrate the continuous check-in points for data collection.

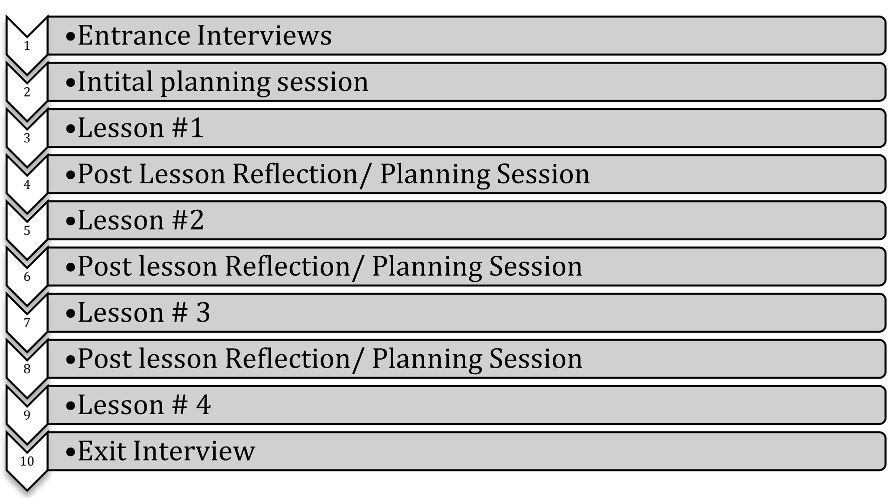


Figure3: Timeline of Major Research Events

All data was uploaded into the qualitative analysis program NVivo. NVivo allows for the creation of nodes, which are categories in which text from various data sources is transferred digitally into categories of reoccurring themes. The initial nodes included topics directly stemming from the research questions (practices, perception, perceived strengths, goals for partnership, etc.). Additional categories and subcategories were added whenever a theme emerged. Two project files were created - one for each participant. Each participant's file included his or her own set of nodes that categorized data sources exclusive to him or her. Data sources featuring both participants were coded separately for each NVivo file. This allowed me to capture each participant's prospective for joint data sources. Nodes that contained isolated comments that did not repeat across data sources or within data sources were dismissed.

Member checks were used throughout the process to assure creditability (Merriam, 2009), which allowed the participants to respond to my conclusions, my perceived observations, and elaborate on anything they said throughout the process.

Findings

This section begins with findings for the unit that Alison and Daniel created. The unit was called "Air as Messenger." The teacher and the scientist were responsible for designing and teaching four lessons of this unit. The afterschool science program met weekly, but lessons were always spaced out so that that a minimum of two weeks intervened between each lesson to allow for communication and planning between the participants. This communication was always in the form of e-mails, and the teacher always finalized and sent out a lesson plan (see Appendix C) prior to the teaching of the lesson.

The theme of “Air as Messenger” was determined in the initial planning period as it was inspired by Alison’s breathing and air-themed lessons in yoga. The “Air as Messenger” unit was aimed at teaching the K-1 students that air is necessary for the transmission of smells and sounds. Animals’ sense of smell and ability to hear would be part of the zoology unit. The lessons were constantly being revised based on new ideas stemming from discussions of previous lessons and the changing nature of the community (i.e., new community members). Table 5 describes the four lessons comprising the unit.

Table 5: Lesson Descriptions of "Air as Messenger" Unit

Lesson	Description
Lesson #1: Air Delivers Smells	Students learned about the human nose and smelled different scents. Some scents were concealed in jars, which led to a discussion on why a lid would make a difference. A rabbit was brought in and observed as he was presented with different smells.
Lesson # 2: Odor Mixology	Students mixed their own scents in jars and compared smells. They experimented with different types of lids to determine if coverage made a difference when detecting odors. A dog was brought in and he had to use his sense of smell to find treats. The treats were concealed in different ways for comparison.
Lesson # 3: Sounds all Around	Students observed pictures of different animals in the wild and compared them to their domesticated counterparts. They discussed why elevated ears would make a difference compared to floppy ears when hearing sounds. They created earmuffs and wore them in order to experience sounds through the perspective of the rabbit. A rabbit was brought in again and observed as he reacted to different sounds.
Lesson# 4: Seeing Sound	A sound amplifier was used to show the movement of sound. Various tones were observed. A dog was brought in again and observed as he listened to different sounds, one of which was a dog whistle. The students interviewed the dog owner about his different reactions to sounds. The lesson ended with a comparison of smell and sound.

Communication and Understanding as Goals

Communication was always at the forefront of the study, as it was a goal for the participants as well. Daniel's goals included exploring methods of communication that nurture questioning. He wrote in the first entry of his reflection journal:

> I once asked a brilliant colleague, a physicist, what he thought the essence of life is. I asked him as a scientist which is to say what can we study and learn about but also as a person and friend. He thought for a few moments and replied 'communication.' It is a very rich answer, true on many levels. (Daniel, Reflection Journal)

In many ways, communication should not have been an issue for two adults, speaking the same language, and working on a joint project. However, Daniel knew that part of his contribution to the community was to explain scientific information to Alison, who had indicated a deficiency of scientific knowledge as one of the reasons she was uncomfortable teaching the subject. There is no argument that the scientific community has specific vocabulary that defines it, even across different fields of science. This language of science also tends to isolate teachers from other communities into the community of science (Moore, 2007). In fact, Alison started this study with notions of science and scientist in stereotypical ways regarding communication with the scientist. When asked to describe a scientist, she said, " A wise guy. I always felt like 'Oh my god, I can't even have a conversation with him.' So intimidating" (Alison, Entrance interview).

Alison's goal for her participation in this study was to increase her comfort level with teaching science. She cited content as the major hurdle holding her back from science. Her childhood experience defined science for her as a textbook study, a memorization of facts and tests that she dreaded. Her negative experience with science was compounded by a lack of science instruction after her high school education. Alison reflected on her experience stating, “It’s like a deep-seated thing from childhood. It’s not enough exposure, not enough play or experiments and so much textbook all through school and no science education. Maybe it’s like this long-felt intimidation” (Entrance Interview).

Below are four themes generated from the analysis of the data sources. They represent communication in science through the use of objects and analogies. Both enabled Alison to build PCK and Daniel to communicate science knowledge in understandable ways.

Using Objects for Science Communication

During the planning session, Daniel attempted to establish communication by using various objects. These were artifacts that he saw as tools that would help him visually explain his ideas. He had a bag full of these objects, which he brought to their planning sessions. The objects included a hand boiler, a pump operated toy cat, and cymbals. This was the dialogue during the Initial Planning Session:

Daniel: Have you seen this? Hold it in your hand?

Alison: Oh it’s a temperature vase.

Daniel: Hand boiler.

Alison: Hand boiler.

Daniel: Yes, so it’s a partial vacuum. So um a little bit of temperature difference moves …moves the air.

This type of interaction, where Daniel brought in science artifacts to share with Alison, happened a few times throughout the meeting, but they always ended abruptly as

Alison did not seem to have any connection to the objects and did not know what to make of them. She reflected on this moment later on in the process during the Exit Interview:

Alison: Daniel was giving all those examples with the toys … he just started pulling all these toys from his bag and he'd experiment with air and I was like okay so what is this? Are we going into air or are we studying animals? You know, so I was still worried at that point.

Interviewer: What kind of toys are you describing?

Alison: I don't remember but there was a dog and the air somehow moved its tail and there was a cat, you know, the tubes that you stretch. I really don't remember.

Interviewer: And how did you feel when he showed you those items initially?

Alison: I felt overwhelmed. Like how am I going to use these, what does he want me to use these for? Where are we going with this? It just felt overwhelming.

With that approach not working, Daniel and Alison started to discuss the breathing lessons he observed her doing with the children when he visited her class for the first time. Daniel recalled that Alison showed the students their breath by using scarves and feathers. They discussed the topic of air and its role when it came to sound and smells. Daniel used his first analogy to make a connection in order to connect the feathers and the scarves with the movement of air. This following took place during the initial planning session:

Daniel: The idea that this invisible medium of air surrounds us. And that sound is movement in the air.

Alison: I don't really understand it to be honest.

Daniel: Did you see the gates exhibit in Central Park? They had orange flags, thousands of them, big ones, held up. Not really flags because there were poles on the end but loose enough that when a puff of wind came through you could see it go down. And it really had the sense of being in this big air that was moving, like a big ocean of stuff that became visible to you. So this invisible air surrounds us….

Perhaps this discussion of air and movement was the pivotal moment that Daniel realized that analogies were an effective method of communicating such complex and abstract ideas to Alison. Data sources from this point showed that Daniel used an analogy at least once whenever he interacted with Alison, especially when explaining scientific content. Even the title of their unit, "Air as Messenger" was an analogy in some respect. It compared the job of a messenger to the role of air.

Analogy for Smells

Alison cited the periodic table in various data sources (entrance interview, reflection journal, and planning sessions) as an ambiguous artifact of the scientific community that confused her:

> As a child growing up in California everyone's outside playing things and mixing things, but I never really saw that as science, science was always kind of kept separate in the lab. When the teacher was just like rattling off and making us memorize the

> periodic table, it had no context for me so when we started doing stuff I didn't know what I was doing and felt stupid. (Alison, Entrance Interview)

Yet when the discussion of smells came up, Alison expressed confusion about why things smell differently and what smells actually were. Daniel started to explain molecules and how they come together, that smells were actual things floating in the atmosphere. He used a molecule set to try to explain but Alison did not understand. Finally, he emailed Alison later that day with an analogy that became a reference point for their discussions when they talked about smells. Daniel related the molecule set to Scrabble tiles, indicating that letters were like atoms and molecules like words. This really hit home for Alison, whose specialty is literacy. She used this analogy during the lesson as Daniel modeled it using different Ping-Pong balls to provide an extra visual.

This analogy also allowed Alison to ask Daniel questions in greater depth as they always had the example of letters and words to use.

In a planning session, Alison wanted to know if there were rules to molecular structure. She questioned whether she could just select any elements from the periodic table and arrange them into a molecule. To that, Daniel reminded her of the conventions of making words and that some rules were common, such as vowel placement and sound chunks. Alison reflected on his use of analogies in helping her understand the concept of molecular structure:.

> His use of analogies brings the scientific content to a level of understanding that I can relate to. Having never had a strong foundation in things like the periodic table, the analogies really help me understand the concepts on a practical level. It doesn't intimidate me as much. I began to see smell molecules as the periodic table (or the letters of the alphabet) coming together to create a scent (like words). That was a very cool analogy and I had never thought of the periodic table that way. In high school and

> beyond it was always just a bunch of letters that made no sense to me. (Alison, Reflection Journal)

Analogy for Sounds

When it came time to transition into the topic of sounds, Alison tried to apply what she learned about smells to form an understanding of sounds. She expressed her confusion as she tried to figure out how sounds could also have molecular structures.

> **Alison:** What's a sound molecule?
>
> **Daniel:** It's not really a different substance but a movement of the substance. In the same way you have a wave in water.
>
> **Alison**: Oh, I see my misconception is that sound is in the air as molecules. (Planning Session)

In this example, Alison was over assimilating by trying to use her new understanding of smells to understand sounds. Luckily, she understood the original concept enough that she realized there was something askew when she tried to use the same reasoning to explain sounds. Daniel used another analogy of "a wave in water," where the sound is the wave and the water is the air, to try to make things more visible for her. The visual of sounds moving through air as waves in the water became one that Alison used to clarify her own thinking and one that was used to explain the concept to the children. This was yet another moment in which Daniel used analogies to communicate concepts to Alison within their community of practice and the same discourse was used to inform her pedagogy.

> It just put things in perspective in a way that I could understand. Instead of talking about molecules floating around or how they were travelling, he would use the image

of a wave crashing into another wave crashing into another wave and that gave me a visual and I think also with kids, they're very visual and very tactile and so the use of those was very helpful. It was kind of bringing the level of understanding from right here over my head to a visual of better understanding. (Alison, Exit Interview)

And once again, Alison expressed in her reflection journal that she had "developed a stronger understanding of the difference between the shape of the air molecules and how sound travels." She felt that, "Daniel's analogies (of a wave crashing for sound and letters/words for smells) provided me with a visual understanding of these concepts and gave me a stronger foundation for teaching them" (Alison, Reflection Journal). Daniel and Alison showed the children the waves or "ripples in the water" by using a bass amplifier. They played various songs, but layered different liquids and grainy material on the speaker to show the movement of sound. Their focus was taking something abstract and making it more concrete. They were taking the invisible and making it observable.

Benefits for Participants

Initially or prior to participating in this study, Alison perceived scientists as "wise guys" who were omnipotent and therefore intimidating. During her exit interview Alison expressed that she still thought of the classic image of the "mad scientist" when she heard the word scientist, and she felt strange considering these ideas because she had a very different experience with Daniel, but she was still honest with what she expressed were deeply embedded perceptions of the scientist figure. Yet, despite this embedded impression of a scientist that she was unable to shake, she was able to overcome a lot of her discomfort with teaching science and her initial fear of teaching science. This occurred, not because she changed her perception of who a scientist is, but because she changed her perception of what science is:

> In the beginning of the study and the initial interview, when you're starting science sometimes I felt like there are these categories that there's these things you have to know and there's the periodic table and there's all this like-- it's known, right? But I think I've learned that sometimes it's okay that it's unknown and we're still discovering it and that there are also opinions, said, 'Well, we don't really know what the dog hears or how many times more.' You look on the internet, it says a dog can hear up to seven times more than a human, but Daniel's like, 'but how do you know? Have you ever been a dog?' That shone a light on me! You read things in books and think that's a fact and you have to second-guess yourself. (Alison, Exit Interview)

Alison starting to reconstruct the study of science not as one in which knowing is a starting point. Rather, science to her became about questioning and feeling okay in not knowing everything. Throughout her experience in the study and working with Daniel, she heard Daniel express several times that he did not know something, but then he would go on to question and reason. Alison was intrigued by the idea that not only did Daniel not know a scientific answer, but that perhaps *nobody* knew.

Daniel experienced his own shift in conceptions throughout the process. His main goal for his own participation in the study was to establish a means of communication that would cultivate questions. His initial approach involved inundating Alison with artifacts that he felt would trigger her interest and bring her closer to science. During his final reflection he commented that Alison was actually always part of the scientific community and that his perceived goal became how to show her that she was. This experience allowed him to develop analogies that cultivated questions. The analogies allowed him to realize that, while some questions could stem out of pure curiosity, Alison needed a familiar point for which to launch her curiosity and trigger her interest. These launching points, known as the source in the analogy (Holyoak & Thagard, 1997), triggered questions to guide Alison towards less familiar and more complex scientific concepts (the target). Essentially Daniel learned that contextualizing instruction is a method that aids in acquisition of scientific knowledge, but also cultivates a sense of inquiry (Rivet & Krajcik, 2007). Furthermore, Alison's own pedagogical strength, specifically her strengths in assessing for understanding, guided the process as she pointed out to Daniel confusing or unrelated information in his instruction.

Discussion and Implications

The purpose of this research is to examine emerging practices that allowed two communities of practice to come together successfully. Findings show that the use of analogies emerged as a shared repertoire. They were used as a successful means of communication between scientist and teacher. The use of analogies became the basis for communication between Daniel and Alison. It not only helped him express complex and abstract ideas to her, but it allowed her to use the same means of communication and adapt it for the lessons.

What is witnessed in this study was the beginning of a process of the use of scientific analogies for communication and understanding. There are certainly limitations for the use of analogies as they can only take the teacher and the learner so far. While analogies are not perfect, the examination of what fits and what does not fit is within itself a useful practice. It is a process of rethinking information and evaluating how the pieces come together. Daniel generated most of the analogies with pedagogical input from Alison. Their conversations shaped the analogies and these conversations demonstrated that Alison had a certain level of comfort and familiarity with the source of the analogy. Yet, her understanding of the original source of the analogy, the analogue domain, was never fully discussed. Therefore, any misconceptions about the workings of the source of the analogy will also transfer to the target, the more complex and unfamiliar concept (Guerra-Ramos, 2010). Furthermore, when the analogies were used with the students, it was assumed that they were also familiar and comfortable with the analogy domain. Perhaps the next step in their community would be the co-creation of analogies. This would then give the teacher and the students more of a sense of ownership of the analogies while exercising a deeper level of thinking in order to generate the analogies. Furthermore, analysis of the limitations of analogies could lead to a deeper understanding of the concept.

The effectiveness of analogies is difficult to assess, they would need to be compared to other teaching methods (Guerra-Ramos, 2010). In this case, direct scientific vocabulary and scientific artifacts were the alternative methods attempted by Daniel, but found to be ineffective. In this study, the use of analogies was the most effective means of communication. Were these the best analogies to use to describe sounds and smells? Glynn (1991) measure the power of an analogy by its components and how much it can be used to explain more source-to-target concepts. In this study, letters were used as representing atoms. The analogy was furthered when words were discussed as molecules (particularly smells). Furthermore, Alison was able to ask about molecular bonding rules by considering phonetic combinations. This analogy allowed for build-up and more source-to-target connections. This was not the case with the movement of waves demonstrating how sound travels. The children were also showed dominoes to help them develop their understanding. This analogy could have been limited by Alison's own previous knowledge of waves and therefore she could not have compared it effectively to the movement of smells (Venville & Treagust, 1996). It might not have been a good analogy because it did not lend itself to multiple components to compare waves to movement of smells. Perhaps multiple analogies could have been developed and selected from, so that familiarity with source domain and lends itself to multiple superordinate concepts (Glynn, 1991).

Once again it should be emphasized that the use of analogies is just a starting point for organizing and presenting ideas. Alison indicated in various data sources that they gave her access to information that was otherwise inaccessible to her. Yet, they should be used cautiously as forming an analogy simplifies, or perhaps over-simplifies a complex topic, which could to lead to the formation of misconceptions.

Through a community of practice perspective, the use of analogies was Daniel's means of brokering (Wenger, 1998) scientific concepts to Alison. It was a way of delivering scientific information without alienating it with scientific jargon. Daniel was in a position to broker, as a member of the teaching community periphery. Unlike most cases of brokering, the analogies did not act as a temporary means for which to link two communities for a joint enterprise. Daniel was not simplifying a concept because he thought Alison could never understand the scientific concept, rather the analogies gave them new terms and jargon - a shared repertoire - exclusive to their community.

Conclusion

Future teacher-scientist collaborations should examine the use of analogies as an effective method of communication that also transfers well into the classroom. There are already publications that provide a compilation of analogies based on individual scientific disciplines (Dagher, 1995; Harrison & Coll, 2007; Levy, 2011; Treagust, Duit, Joslin, & Lindauer, 1992). While these resources might be helpful tools for teachers, the natural formation of analogies informed by teacher-scientist conversations is more consistent within a communities of practice mode. Here, discourse and repertoire are established from within. In essence, the purpose of this study has never been about creating a perfect analogy; it has been about creating a community.

Chapter VI

DISCUSSIONS AND CONCLUSIONS

The purpose of this ethnographic study was to study an emerging culture involving a community of practice between an elementary educator and a scientist. Mutually beneficial practices have been identified in order to shed light on practices that can be used for professional development. Emphasis is placed on the benefits being mutually beneficial as both members needed to gain from the community. Table 6 summarizes the benefits for the teacher and the scientist:

Table 6: Summary of benefits for each participant

Benefits for Scientist	Benefits for Teacher
• Improved upon his methods for communication (analogies). • Built upon his scientific content knowledge as he explained and researched topic • Built upon his appreciation for teachers and their ability to nurture questions.	• Reconstructed her understanding of science, which was more attainable to her. • Gained pedagogical content knowledge skills (use of analogies) • Gained scientific content

The autonomy given to the research participants to create their own-shared repertoire (Wenger, 1998) was essential in allowing the scientist and the teacher to establish their own community practices. These practices included selecting a unit topic that was connected to the teacher's strength and interest. This gave the teacher an initial connection to science, a subject that she felt isolated from. The scientist was able to identify this interest because of a self-initiated visit that he requested prior to their initial planning meeting. This observation allowed the scientist to see the teacher's pedagogy in action and develop a stronger sense of how he could develop his own communicational skills.

Findings also demonstrated that the need for additional community members became necessary as the scientist and the teacher recognized their own limitations. They sought out other members to expand their community and further diversify the skill set.

The actual teaching of the lessons was important in order to link knowledge and practice. It was left up to the participants how they would negotiate their roles and share responsibilities as they taught the lessons to children. Findings show that the teacher took on most of the pedagogical responsibilities as the scientist respected her expertise and high skill level when interacting with children. The scientist took on more of the role as assistant and aided her by providing visual demonstrations to compliment her instruction.

The goals of the scientist to nurture questions and improve methods of communication were addressed. The scientist settled on analogies as the most successful method to communicate information. It also helped generate questions, as the limitations of the analogies were explored. This process dug up misconceptions and established a forum for further exploration of content. Table 7 provides an overall summary of the findings as they directly pertain to the research questions:

Table 7: Summary of Findings Related to Research Questions

Research Questions	Summary of Findings
What are the characteristics of a teacher-scientist community of practice (i.e. shared repertoire)?	• Autonomy to explore interests and challenges unique to every community. • Establishing goals and identifying strengths/ interests early on in the collaboration • Respect for distributed knowledge and skill set within the community

What practices are mutually beneficial in an elementary educator- scientist community of practice as a means of professional development?	• Participating in a pre-planning visit • Creating a self-generated topic stemming from group interest • Expanding community membership • Negotiating roles within the classroom • Use of analogies to broker information • Establishing and sharing goals (confirmed from previous research) • Holding regularly scheduled meetings • Maintaining email correspondence to finalize lessons
How does participation in the community of practice affect the members' perceptions of one another?	• Teacher maintained her original perception of scientists. • Teacher changed her perception of the practice of science to be more encompassing and explorative. • Scientists developed a deeper respect for pedagogical skills and maintaining a level of excitement that is contusive to learning.
How can practices be brokered to overcome boundaries between the education and scientific community?	• Use of analogies • Using interdisciplinary approach that accounts for participants' interest.

Connections to Theoretical Frameworks

The theoretical frameworks for this study add depth to the findings and shed light on the intricacies of the relationship between the two participants. This was not just a partnership between any two communities, it was a special partnership between two communities that have existed in isolation. Elementary educators as generalists have not received training or experience develop a subject matter identity that incorporates science. While they are called upon as part of the educational puzzle that prepares the next generation of scientists, they themselves do not feel connected to that. Through Carlone and Johnson's Model of Science Identity it is clear to see that elementary educators are, for the most part, missing all three components that would allow them to develop a positive sense of self in the scientific community: scientific content knowledge, scientific skills, and acknowledgment of membership from members of the scientific community.

I analyzed Daniel's experiences through a lens of theoretical frameworks: Subject Matter Identity and Carlone and Johnson Model of Science Identity. This analysis presented something completely different compared to an elementary educator's. Daniel understands that he does not need to know about everything to be a good scientist, but he was confident enough in his knowledge and scientific skills, which Carlone and Johnson (2007) identify as competence and performance. His various references to working with other members of the scientific community demonstrate the third component for a positive science identity: recognition. Yet a strong sense of self as a "science person" does not necessarily transfer to an ability to teach science. A subject matter identity comes from experience in teaching a subject while gaining the pedagogical skills required to teach that subject (Helms, 1998). This is what Daniel felt needed more development and his reason his participation in the study.

Taking all of the aforementioned into consideration it is clear why a community of practice was a suitable major framework for this study. Subject Matter Identity, and Carlone and Johnson's Model of Science Identity, allowed me to understand the troubles that elementary educators would have connecting to the scientific community. These two theoretical frameworks presented a strong science identity for Daniel, but also shed light on his need for developing skills to communicate knowledge. The Communities of Practice framework made it possible to break away from the deficit perspective when forming an understanding of both the elementary teacher and the scientist. It set a perspective that permitted discoveries within the study that otherwise may have been overlooked, especially how the interaction between the participants was explained; everybody involved had something to contribute, and everybody within the community had something to gain. Focusing on the deficit (elementary educators need content knowledge or scientists can not communicate effectively) would have once again created an environment where someone is lesser and hierarchies would stunt the development of a joint enterprise. Communities of Practice, as a theoretical framework, has its limitations as a theoretical framework, as it is not a lens for looking into identity development. This is why it was necessary to supplement with Subject Matter identity and Model of Science Identity in order to gain more insight on each individual participant.

Implications for Future Professional Development

While there is a benefit to allowing a community to establish practices with minimum outside interference, there are certainly a lot of professional development models that offer structured guidelines to assure maximum success. Therefore, I feel that the findings (establish shared repertoire discussed in Chapters 4 and 5) can be used to establish beneficial practices early on in the course of the partnership, while still maintaining enough autonomy for each community to develop independently.

Past research places the majority of the emphasis on how much the teacher benefits for working with partnerships (Anderson, 1993; Caton, Brewer, Brown, 2000; Gottfried, Brown, Markovits, Changar, 1993; Kenny, 2012; National Research Council, 1997) As previously discussed, partnerships in which the scientist is not expected to develop professionally makes the teacher feel inferior. This study shows the rich experience and development that the scientist gained from being part of the community. The scientists worked in an environment with a skilled educator in which true understanding and development of questions was at the forefront. He reflected that teaching someone (Alison) who was simultaneously cognizant of how individuals learn, gave him an opportunity to develop his pedagogical skills and develop practices that cultivated the sharing of knowledge in their community. Future professional developments should approach collaborations between elementary educators and scientists as mutually beneficial. This not only sets the tone for a healthy community of practice, but might also help in securing funding that would only be available to scientists' professional development.

Future Research

This research study was meant to add to the sparse research surrounding the elementary educators' community and their true collaborations with scientists. Therefore there is much to be done in the way of future research. This study followed the collaboration of a teacher and scientist in an afterschool program at a private school. This was purposely done in an environment unrestricted by state mandated standards and removed from the schedule of the usual day so that the community could develop with minimum restrictions. Yet, the question remains as to how this model would work when introduced in a high stakes testing environment where teachers need to meet the demands placed on them in literacy and mathematics before science (Berg & Mensah, 2014; Spillane et. al, 2001).

Additionally, future research should explore the long-term impacts of this partnership and how the scientist and the teacher were able to bring into their practice. While the two participants expressed in their exit interview that this experience has already shaped their practice, future research could provide specifics as it connects to student engagement, interest, and achievement in science.

Conclusions

The purpose of qualitative research is not to create a formula in which future participants can be plugged in, yielding the same results. It is about painting a picture, capturing a voice, and understanding patterns of human behavior and interaction. Capturing the development of this community, this ethnographic study identifies beneficial practices that can be used to shape future elementary teacher-scientists collaborations. The relationship between Alison and Daniel is unique and, on many levels, cannot be replicated. However, they developed a shared repertoire of practices in a new community of practice of their own that was able to meet their professional needs and bring their respective communities of practice together in the shaping of a new one. Therefore, we can learn from Alison and Daniel's experiences and apply them to future interactions.

At its very essence this research demonstrates the benefits of establishing dialogue between two very different communities, which can be benefited from in many aspects of our society. If two communities are out of touch with one another, if their only reference of each other is based on stereotypes and isolated negative experiences (Mensah, 2011), does it not make sense to simply bring them together? Let them establish a dialogue and an exchange of practices so that they can bridge the gap between their communities so that they can gain from each other's knowledge and skills.

Epilogue

I started this dissertation by citing my experience as a pre-service teacher in a Masters program making big plans to teach my students everything they needed to know. I want to go back to that moment to conclude this dissertation. As it was, my big plans were clouded by unfortunate realities and I did not teach science for the first few years of my career. My science professor in that Masters Program was Dr. Felicia Mensah. She later became my advisor and mentor. After reading my dissertation, she asked me what people should walk away from it knowing.

Implications for professional development were discussed earlier in this dissertation, but that is not the essence of this research. Rather, it is one piece of the puzzle. I told Dr. Mensah that every school proudly boasts a philosophy of education and sets goals for their students. However, no matter what the philosophy is, I believe that it cannot be met without proper science education. To understand this claim, we must all restructure what science is, as did Alison. By the end of the study she saw it as all encompassing, as one of the key ways to understand the world around us and operate effectively and responsibility within it. How can we meet *any* philosophy of education without science education?

If science is not given to all, then knowledge becomes something for a select few. That is a dangerous premise and one that we must avoid. Scientists have developed the reputation of being intimidating and disconnected with the masses. What does that say considering the fact that their main focus is to help understand our world? Partnerships like the one described in this dissertation attempt to break down these boundaries so that knowledge is redistributed. This is not merely done by learning scientific content, but rather by redefining what science is and who it is for. What I see in this dissertation is the breaking down of boundaries for the benefit of the participants and the students.

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APPENDICES

APPENDIX A: ENTRANCE INTERVIEW QUESTIONS

FOR TEACHER:

Identity and Professional Identity

- Describe your role at the school
- How did you enter the field of teaching? What made you pick elementary education?
- Do you perceive yourself as a member of the educational community?
    - If yes, in what ways? If no, why not?
- Do you perceive yourself as a member of the scientific community?
    - If yes, in what ways? If no, why not?
- How do you feel like you most contribute to your professional community?

- Which area(s) do you perceive to be your strength as an educator?
- Which area(s) do you think you need to grow or develop in?

Subcategory Under Identity Perception of Scientists

- What comes to mind when you think of a scientist?
- Do you think scientists would welcome you in their community of practice?

Content Knowledge

- What were your experiences like in science as a student: elementary, middle, and high school?
- What do you remember about your science teachers in each of these grade levels?
- Describe your science coursework in college.
    - What science classes did you take?
- Describe your college coursework while getting your teaching degree
- How comfortable do you feel with your knowledge of science?
- What kinds of science professional development have you had as a teacher?
- Have you worked with a scientist previous?
    - If so, in what way?

What do you hope to gain from your participation in this research?

FOR SCIENTIST:

Identity and Professional Identity

- Describe your work
- How did you enter the field of science? What made you choose your specific focus?
- Describe your role as an educator
- Do you perceive yourself as a member of the educational community?

  - If yes, in what ways? If no, why not?
- Do you perceive yourself as a member of the scientific community?
  - If yes, in what ways? If no, why not?
- How you do you feel like you most contribute to your professional community?
- Which area(s) do you perceive to be your strength as a scientist? As an educator?
- Which area(s) do you think you need to grow or develop in?

Subcategory Under Identity: Perception of Teachers

- What comes to mind when you think of an elementary school teacher?
- Do you think teachers would welcome you in their community of practice?

Content Knowledge

- What were your experiences like in science as a student: elementary, middle, and high school? What do you remember about your teachers?
- Describe your science coursework in college (BA)
- How comfortable do you feel with your knowledge of science?

What do you hope to gain from your participation in this research?

Note: These questions were only used as launching points for the conversations. Several other questions were asked throughout the interview

APPENDIX B: EXIT INTERVIEW QUESTIONS

<u>FOR TEACHER:</u>

Identity and Professional Identity

- In your own words, describe your work with the scientist.
- Which practices were beneficial when working with the scientist?
- What did you perceive your role to be in this community?
- How do you feel the partnership has impacted you currently as an educator?
- Which area(s) do you perceive to be your strength as an educator?
- Which area(s) do you think you need to grow or develop in?

Subcategory Under Identity Perception of Scientist

- What comes to mind when you think of a scientist?
- Do you think you were welcomed into the scientific community?
- Do you perceive yourself as a member of the scientific community?

Content Knowledge

- o Describe your acquisition of scientific content knowledge as part of your participation in this study
- o How comfortable do you feel with your knowledge of science?

What, if anything, do you feel that you gained from your participation in this research?

<u>FOR SCIENTIST:</u>

Identity and Professional Identity

- In your own words, describe your work with the teacher.
- Which practices were beneficial when working with the teacher?
- How do you feel the partnership has impacted you currently as a scientist?
- What did you perceive your role to be in this community?
- Do you perceive yourself as a member of the educational community?

Subcategory Under Identity: Perception of Teachers

- What comes to mind when you think of an elementary school teacher?
- Do you were welcomed into the teaching community?

Content Knowledge

- Do you feel that this experience impacted your scientific content knowledge?

Note: These questions were only used as launching points for the conversations. Several other questions were asked throughout the interview.

APPENDIX C: LESSON PLANS

Lesson #1: Air Delivers Smells

Essential Questions: What is the purpose of the nose? How does smell reach our nose? How does the nose communicate the smell to the brain?

Introduction:
Show a close-up photo of a human nose and some animal noses (bunny, dog, bear, cat). Discuss the function and purpose of the nose. Take some deep breaths in and out of the nose.
-introduce some jars of smell (lemon, carrot, celery, vanilla extract)
-have some jars with leaves, flowers (some dry, some moist)

Discussion of how some smells are stronger. close eyes and try to identify. Discuss why we cannot smell the items when the jar is closed. Daniel explains how the invisible molecules float out of the jar and reach our nose. Why do the moist leaves smell stronger?

Story-time
-launch into bunny storytelling: Alison's observations of her bunnies as a child (nose twitching, hopping towards smell, love for flowers especially after a rain) Maybe I tell the story without telling them the animal, then we do rabbit yoga pose and they have to guess the animal and identify the nose from the intro photos.

Bunny Time!
-Pancake the bunny comes in! We observe him, touch him, watch his nose. Let him hop around and smell the items we have out. Start with the carrot and celery, which does he prefer? Ask his owner questions: what are his favorite foods?

-Take out the leaves and flowers and put in low dishes for Pancake. Which does he gravitate towards? Talk about how this could help an animal distinguish smells in nature.

Closing discussion:
Air carries the message of smell. Daniel provides a visual image of a smell traveling through air. (red ball among millions of white balls) closing discussion of jars vs. open containers. Why were the smells stronger? How does our nose communicate the smell message to our brain?

Materials needed:
Jars
low dishes (like take-out containers)
lemon, celery, carrot, vanilla extract (I'll bring the vanilla, I have several!)
animal and human nose photos: we can pull these up on the screen
leaves and flowers
image of smell (red ball, white balls)
Pancake :)

Lesson#2: Odor Mixology

Intro:
Modeling to the whole group with the jar. The jar is closed. Can we smell what is inside? Why not? What would happen if we open it? Can we smell? Why?
We are thinking of using a hot, mulling spice as this demonstration smell, so that the smell is transmitted through the steam when we open it. We ask, "How do we smell?" The scholars will hopefully conclude that the steam is carrying the smell.

Group Work:
We break up into 2 groups. Each child gets a jar with a different smell (maybe even combo smells!) Daniel and Alison lead the group in another discussion about whether or not they can smell the item with the lid on the jar. Predict what will happen when the jar is opened. What do you smell? How are you smelling it? Is there vapor this time? If not, then what is carrying the smell?

Back to the whole group:
Conclusion: What carried the smell to our nose? If the air is carrying it, why are some smells stronger?

Bunny Storytelling/yoga pose: guess the animal!

Bunny Time! Pancake visits, we observe him, observe his nose, watch him hop around and smell. He may be a bit nervous, so if he is reluctant to smell, we can discuss that. When we are nervous, are we thinking about smelling and eating, or something else?

Concluding discussion:
Animals use their sense of smell---how is this smell transmitted to their nose? We discuss the importance of air and the messages and stories it carries to us through smell.

Lesson 3: Sounds All Around

-Short video of a bunny in the wild with tall ears, observe behaviors

-Discussion of the shape of the ear: how does the tall ear help the bunny in the wild? The ears can rotate back and forth, and they can move their ears independently of one another to pinpoint danger. When the bunny is relaxed, the ears lay alongside the back. The bunny can lie low in tall grass to hide, but can keep its ears up to detect sound.

-Compare photographs of lop-eared and tall ears, up close. Talk about the differences. What could be a potential problem for lop-eared bunnies?

Experiments with sound and how it travels:
-Through air (watching the dominoes fall, analogy of molecules bumping into one another)
-through solid (putting ear on table and tapping or knocking)

-Now try the same experiment with muffled ears to imitate Pancake's floppy ears (we can use jumbo-sized pom poms to hold against ears, like ear muffs!)

Pancake visits!
Observe Pancakes ears as he hops around. Let's be very quiet, and then make some light humming sounds. Let's try tapping the floor gently. Interview Heather and her own observations of Pancake's hearing, what she has noticed, and research she has done!

Lesson #4 Seeing Sound

Intro: Begin with a yoga game: "Meet your animates"
Each scholar is given an animal card (bird, dog, bear, mouse) and they have to move around the rug like the animal, making the sounds of the animal, and try to locate their mates. We will play two rounds: in the second round, they will only move in silence.

Discussion: Which animal sounds were you able to hear better? The deep bear growl or the high-pitched bird or mouse chirp? Which round was easier? The one with animal noises or no noise at all? Talk about what a dog needs to be able to hear in the wild. Is the dog the predator or the prey? How far do you think a dog sense of hearing extends?

Why not also have people mime what it is like to be a sound traveling through air and to be a molecule that smells a particular way? I will try to incorporate that into my part. I can't wait to see what shape they take when I ask them to imagine and make their bodies into the shape of a molecule that smells like Alison's delicious baked apple.
Or like a water molecule. Or a gas molecule.

Benji Visits!
-Play the yoga "animate" game one more time, this time with sound and movement. Which animal group does Benji gravitate towards?

How to express friendly playfulness? Maybe this is something to discuss even before Benji comes in. How is the best way to express kindness to Benji different than it would be to the rabbit?

Or perhaps he jumps around and visits all of them out of sheer excitement :)
-Experiment with the dog whistler. How does Benji respond?
-Interview Lindy What does Benji typically bark at? After a few examples, see if we can begin to gather information and form conclusions about his hearing. A dog can hear sounds farther away from a human, about 4x as further! They can also hear at higher frequencies. What does this mean?

There is a really interesting video and article about how dogs wag their tails differently when they are friendly and not friendly. Not too surprisingly other dogs are very good at reading this body language.

Empathy
Hearing like Benji...When we crash two cymbals together, that may be the sound Benji hears when we just hear a 2 plastic bowls clang together. Experiment with both.

Molecules and energy.....
Yoga scarves: play around with blowing them. What's moving the scarf? Air!
Yoga scarves on the amp. What's moving the scarf now? Sound!
Can sound move smell? sprinkle some cinnamon on the yoga scarf. Put it on the amp. What happens?

Nermeen, let's make sure the 'new' amp I brought in will do the job or borrow another one from Annie.

Daniel brings out the molecule model kit. This time, I think it's best Daniel if you teach directly and use your analogy of letters and words. Now that the kids have had some exposure and some conversations, it would be good to hear your explanation to tie things together. Talk about smell molecules being different shapes; compare a couple of shapes with the model kit.

Compare smell to sound. I like the analogy you gave me last time about the ocean, waves pushing one another is a great visual for sound being carried by air.

APPENDIX D: TEACHERS COLLEGE IRB APPROVAL

TEACHERS COLLEGE

COLUMBIA UNIVERSITY

OFFICE OF SPONSORED PROGRAMS

Institutional Review Board

May 15, 2014

Nermeen Dashoush
550115th Avenue, Apt. 4E
Brooklyn, NY 11219
Dear Nermeen,

Please be informed that as of the date of this letter, the Institutional Review Board for the Protection of Human Subjects in Research (IRB) at Teachers College, Columbia University has reviewed your study entitled *"Establishing a community of practice between elementary educators and scientists as a means of professional development"* under Expedited Review (Category 7).

The approval is effective until May 14, 2015.
The IRB Committee must be contacted if there are any changes to the protocol during this period. Please note: If you are planning to continue your study, a Continuing Review application must be filed six weeks prior to the expiration of the protocol. The IRB number assigned to your protocol is 14-249. Feel free to contact the IRB Office [212- 678-4105 or hersch@tc.edu] if you have any questions.

Please note that your consent form bears an official IRB authorization stamp. Copies of this form with the IRB stamp must be used for your research work.

Best wishes for your data collection. Sincerely,

TEACHERS COLLEGE, COLUMBIA UNIVERSITY
INSTITUTIONAL REVIEW BOARD
Protocol # 14-249
Consent form approved until 5/14/2015
IRB Signature SH

Karen Proud, Ph.D. Associate Professor of Speech and Language Pathology Chair, IRB

Teachers College, Columbia University
525 West 120th Street

New York NY
10027 212 678
3000

www.tc.edu

Informed Consent

DESCRIPTION OF THE RESEARCH: You are invited to participate in a research study on teacher- scientist collaboration as means of professional development. You will be asked to participate in an entrance interview, which will be recorded and transcribed. Upon completion of this interview all identified goals will be shared in written form with the other participant in the study. The second component of this research requires you to work with the other participant to plan a four-lesson science mini-unit. This involves meeting with the other participant a total of four times for planning and reflection. These meetings will be audio-recorded and transcribed. You will be working with the other participant to teach the lesson and the extent of your participation will be determined by you both in planning meetings and during the lesson.

The research will be conducted by the researcher, Nermeen Dashoush, a Doctoral Candidate in the Science Education Program at Teachers College, Columbia University. The research will be conducted at the school employing the teacher participant.

RISKS AND BENEFITS: The risks for participating in this research study are expected to be minimal such that they are not above and beyond what is encountered in everyday life. If you encounter discomfort in answering any of the questions in this study, please feel free not to answer them. You will not be penalized in any way if you do not answer certain questions or if you choose to no longer participate in this study. There are no direct benefits to participating in this study. It is my hope that your participation will provide researchers and practitioners alike with information and insight regarding your experience.

PAYMENTS: There will be no payment provided by myself to the participants. However, the teacher participant will be compensated as an employee of the school teaching an extra curricular program.

DATA STORAGE TO PROTECT CONFIDENTIALITY: All personal identifying information will be kept private and confidential. Your names and any identifying information will not be published or shared with anyone besides the principal investigator. If notes are taken in a notebook they will be locked in a filing cabinet in the principal investigator's home. The online journal will be in the form of

a GoogleDoc that is only accessible to the researcher and the assigned participant. Upon completion of the journal, the document will be downloaded to the principal's investigator's password protected computer.

TIME INVOLVEMENT: Your participation will take approximately an hour for the entrance interview. The planning meetings (four total) are all ranging from 30-45 minutes each. Each lesson (four total) requires an hour-long commitment. Journal entries will follow each lesson (4 total) and will take approximately 30 minutes to complete each entry. Your participation in an exit interview will also take approximately an hour. All dates for interviews, lessons and planning meetings will be determined by the participants of the study based on individual and mutual availability.

HOW WILL RESULTS BE USED: The results of the study will be used to inform my dissertation in understanding the nature of a teach-scientist community of practice. It is possible that the results of this study may be utilized for future educational publications and/or conferences/presentations.

Confidentiality will be ensured at all times.

TEACHERS COLLEGE, COLUMBIA UNIVERSITY
INSTITUTIONAL REVIEW BOARD
Protocol # 14-249
Consent form approved until 5/14/2015
IRB Signature SH

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Participant's Rights

Principal Investigator: **Nermeen Dashoush**

Research Title: "ESTABLISHING A COMMUNITY OF PRACTICE BETWEEN ELEMENTARY EDUCATORS AND SCIENTISTS AS A MEANS OF PROFESSIONAL DEVELOPMENT"

- I have read and discussed the Research Description with the researcher. I have had the opportunity to ask questions about the purposes and procedures regarding this study.
- My participation in research is voluntary. I may refuse to participate or withdraw from participation at any time without jeopardy to future medical care, employment, student status or other entitlements.
- The researcher may withdraw me from the research at his/her professional discretion.
- If, during the course of the study, significant new information that has been developed becomes available which may relate to my willingness to continue to participate, the investigator will provide this information to me.
- Any information derived from the research project that personally identifies me will not be voluntarily released or disclosed without my separate consent, except as specifically required by law.
- If at any time I have any questions regarding the research or my participation, I can contact the investigator, who will answer my questions. The investigator's email is nd2133@columbia.edu and questions can be answered via email or by establishing an in person meeting or phone conference.
- If at any time I have comments, or concerns regarding the conduct of the research or questions about my rights as a research subject, I should contact the Teachers College, Columbia University Institutional Review Board /IRB. The phone number for the IRB is (212

678-4105. Or, I can write to the IRB at Teachers College, Columbia University, 525 W. 120[1]

Street, New York, NY, 10027, Box 151.

- I should receive a copy of the Research Description and this Participant's Rights document.
- If video and/or audio taping is part of this research, I () consent to be audio/video taped. I ( ) do NOT consent to being video/audio taped. The written, video and/or audio taped materials will be viewed only by the principal investigator and members of the research team.
- Written, video and/or audio taped materials:

  () may be viewed in an educational setting outside the research

  ( ) may NOT be viewed in an educational setting outside the research.
- My signature means that I agree to participate in this study.

Participant's signature:________________________Date:____________________

TEACHERS COLLEGE, COLUMBIA UNIVERSITY
INSTITUTIONAL REVIEW BOARD
Protocol # 14-249
Consent form approved until 5/14/2015
IRB Signature SH

Name: Nermeen Dashoush

Investigator's Verification of Explanation

I certify that I have carefully explained the purpose and nature of this research to —————— in age-appropriate language. He has had the opportunity to discuss it with me in detail. I have answered all his questions and he/she provided the affirmative agreement (i.e. assent) to participate in this research.

Investigator's Signature:______________________

Date:______________