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Teacher Professional Knowledge Building Networks: Creating Opportunities for Teacher-Shared Knowledge Creation

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by

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ABSTRACT

The purpose of this study is to explore the extent to which the development of a professional knowledge building network could increase the collective knowledge building and shared learning of teachers within one rural Alberta school division. The goal of this case study research is to examine the ways teachers share and build professional knowledge within a networked environment and identify specific inhibitors to knowledge building that may impact effective shared knowledge creation.

A *Conceptual Framework for the Creation of Shared Professional Knowledge* was developed for this case study that provided a better understanding of knowledge building among teachers, as well as specific design features needed in a professional knowledge building network. Throughout this case study, different data sources such as questionnaires, semi-structured interviews, server log data, and card sorts provided a variety of personal perspectives and experiences with regards to professional knowledge creation shared among teachers.

The findings from this study identified several Knowledge Building Inhibitors that impact the successful sharing and building of knowledge. This study also highlighted the importance of relational trust with regards to successful knowledge building and indicated that teacher expertise plays an important role in knowledge reciprocity. Overall, this research study provided a unique perspective with regards to effective teacher-shared knowledge creation within a knowledge building network.

DEDICATION

For Dr. Pamela Bishop.

You always believed in me and supported me as a leader, educator, and researcher.

I am eternally grateful to you.

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CHAPTER ONE: INTRODUCTION

Educators are working in a complex environment where knowledge and innovation are at the forefront for both teaching and learning. Mechanisms and structures developed to promote knowledge building and sharing have become the cornerstones of organizational improvement and change. As educators continue to move further into a global society, where knowledge is vast and universally accessible, the way they access, use, and transfer knowledge within the classroom may need to change. Scimeca, Dumitru, Durando, Gilleran, Joyce, and Vuorikari (2009) warned that formal educational institutions are continuing to "operate in a classical information delivery paradigm which does not consider the increasing impact and the changing nature of social interaction and knowledge creation" (p. 489). To support the collaborative social processes associated with shared knowledge creation within their classrooms, educators need to experience their own forms of knowledge creation and knowledge building. Therefore, the development of a broad interconnected professional knowledge building network has increased relevance for providing meaningful knowledge building experiences for educators. Further, it will help to shift the focus of professional learning from knowledge replication and retrieval to a more collective notion of shared knowledge creation.

Problem Statement

High quality professional learning experiences are needed to ensure teachers are equipped with the skills and specialized knowledge required to prepare students for a complex world. Hargreaves and Fullan (2012) emphasized that individual talent will only have a small-scale impact on teacher learning. It is the collective ability of teachers working together that will increase the professional capital of the teaching profession. In a recent study conducted by the Alberta Teachers Association on teacher professional learning, 80 percent of respondents

reported that their best professional learning opportunities occurred when there was collaboration with colleagues (Beauchamp, Klassen, Parsons, & Taylor, 2014). Yet, many school districts still view teacher professional growth as an individual endeavour. A shift is required with regards to teacher professional development that moves from the more traditional professional learning models that focus on the development of individual teacher skills and expertise towards a more collective process where the social organization of teacher learning encourages shared knowledge advancement.

Many dynamic and collaborative platforms are available for professional learners to meet and share resources online, but their ability to effectively support shared knowledge creation is often limited. According to Scardamalia and Bereiter (2003), new emerging technologies are constantly being created and "collaboration, discussion and information sharing may all increase, but if there are no knowledge advances, we do not have an effective knowledge building environment" (p. 8). The problem facing many educational systems is finding a structure that is robust enough to store teacher resources while also providing a responsive and flexible environment that effectively supports teacher-shared knowledge creation.

Statement of Purpose and Research Questions

Teacher professional development is of increasing interest to researchers and educational leaders because it provides an area of support that is directly connected with improved student learning (Wei, Darling-Hammond, & Anderson, 2010). Often what is found in current professional development initiatives are ineffective structures that are not capable of supporting sustainable change in current teacher practice. Research has indicated that there is a correlation between high quality, sustained teacher professional development and improved student achievement (Borko, 2004).

Allen and Cherrey (2000) indicated that two major shifts in the world are having an impact on how we work and collaborate. The first shift is a movement from a world of fragmentation to one of connectivity; the second is from an industrial age to a knowledge age. Both shifts present an interesting challenge for school districts to provide teacher professional learning that can provide sustained learning for all teachers. Fullan and Langworthy (2014) also emphasized that our economies are shifting; and new deep pedagogies for teachers need to be developed where the creation and use of new knowledge is at the forefront of teacher learning to better support innovation, creativity and ongoing collaboration. In response to this challenge, this study has designed a professional knowledge building network that focuses on the building of new teacher professional knowledge and supports collective innovation.

Often in teacher professional learning models, the focus is on learning and acquiring knowledge as an individual rather than collectively building and sharing knowledge. The strength of a knowledge building community is that it shifts the focus of professional development from individual teacher improvement to a larger focus on enhancing a professional community. In a knowledge building community, the expertise, skills, and experiences of individual teachers are combined to advance the state of knowledge for all rather than celebrating the accomplishments and achievements of a few. A main premise of shared knowledge creation and knowledge building is that individuals come together as a collective body to work towards the continual advancement of community knowledge.

Regarding teacher professional development, creating a space where teachers could move towards the development of a knowledge building community would promote the concept that "people are not honoured for what is in their minds but for the contributions they make to the organization's or the community's knowledge" (Scardamalia & Bereiter, 2006, p. 98). This is a

key distinction that moves teacher professional development models from individual information gathering events to a collaborative endeavour where teachers come together to explore, develop, and share co-constructed knowledge of teachers' professional practice.

The purpose of this case study was to explore the extent to which the development of a professional knowledge building network could support shared knowledge creation and learning in one rural school district. The findings from this study are designed to help school districts develop effective organizational structures that nurture and support shared knowledge creation and innovation with regards to teachers' professional practice. The study was designed to answer the following questions:

1) How can the development of an online knowledge building network influence teacher-shared knowledge creation?
    a) How do teachers build and share knowledge in a networked environment?
    b) How do the connections between teachers impact shared knowledge creation?
    c) What knowledge building barriers impact a networked environment?
    d) What types of features are required to create an effective knowledge building network?

Context of the Study

Effective teacher professional development must transform teacher practice that results in improved student outcomes (Darling-Hammond & Richardson, 2009). In a background paper co-authored by the members of an External Advisory Committee for Workforce Planning and Development, key pieces of an Alberta provincial policy framework for teacher professional learning were introduced. The authors concluded that teacher professional learning should:

- Be intensive, ongoing, and connected to practice;

- Focus on student learning;
- Align with school improvement priorities and goals;
- Promote strong working relationships and collaboration among teachers.

(Alberta Education, 2010, p. 6)

School divisions across Alberta continually seek to include the above characteristics in their division's professional development models. Many divisions have increased the time allocated for collaboration among their teachers with regards to professional learning and recognize that the specialized knowledge of individual teachers is their primary asset for achieving continual improvement with regards to student learning. The challenge for these school districts is that teacher expertise and knowledge is often deeply embedded within individual professional practice and can be difficult to articulate and even more challenging to share.

A strategic goal for the rural school division selected for this case study was to develop a teacher professional learning model that would promote collaboration and ongoing professional development for their teachers across the division. A key challenge for this school district is that it is geographically vast with many small school centres scattered throughout the division. Teachers in the division can often find themselves in schools where they are the only subject specialist or grade specialist.

Currently, the school district provides four professional learning days throughout the school year where teachers can come together across the division and collaboratively meet with their other grade or subject teachers. The challenge with this model is that it does not allow for the intensive and ongoing professional development needed to encourage effective collaborative, pervasive idea exploration, and effective knowledge sharing. Instead, these professional learning

communities were often fragmented and disjointed. Some teachers opted out of the days because they felt their individual learning needs were not being met, while others began collaborative work that was never completed because of a lack of time or focus. Teachers in the division often expressed an interest in finding a common platform where they could continue to come together to share ideas and build resources for their various grade and subject areas. Although multiple online tools were explored and tested, no one tool seemed to effectively meet the needs of all teachers.

It was this lack of an effective tool to support the work of teachers that sparked my interest in developing a digital space where ongoing and intensive professional learning could occur and be effectively supported. I also began to explore the advantages of supporting knowledge building and sharing among teachers as a key driver of effective teacher professional development.

Rationale of the Study

As educators continue to function within the knowledge age, the collective sharing and development of new knowledge has the capability to surpass individual expertise. The Organisation for Economic Co-operation and Development (OECD) program on *Schooling for Tomorrow* (2000) explored the potential of learning networks on student learning and teacher practice. They found that professional networks in education promoted not only the exploration of good practice, but also enhanced professional development and assisted in the process of re-culturing educational organizations and systems. Engeström (2008) also suggested that sustained, creative knowledge work can be better supported through distributed, flexible, and adaptive social structures rather than centralized, rigid, and fixed structures. This type of re-culturing of teacher professional development would mean moving from a knowledge retrieval system, which

can often be seen in the workshops and large professional conferences that are offered to educators presently, to a knowledge creation environment that embraces a more communal approach to learning.

The European Schoolnet (1997) is an example of a professional learning network that supports 30 European Ministries of Education and promotes the integration and development of research-based teacher practices and changing technologies. The strength of professional learning networks like the European Schoolnet (1997) is that they grow with their users and offer an asynchronous platform that supports the development of innovation, learning, and shared knowledge building within an interconnected networked environment. A professional knowledge building network could offer similar extended opportunities for the advancement of shared ideas, while also providing a variety of digital knowledge building tools that support the creation of "living entities that evolve and change, while being deeply connected with the reality they develop" (Scimeca et.al, 2009, p. 490). These new living entities of shared knowledge could help transform teacher professional development from individualization and fragmentation to collective knowledge building and shared meaning making.

By creating a professional knowledge building network, my study set out to provide teachers with a platform for continuous teacher learning that moves beyond workshops and episodic events. Instead, it was designed to support the process of collective knowledge advancement and sustained professional development within an asynchronous knowledge building network environment.

Significance of the Study

The movement towards a knowledge age has led educational leaders to reconsider what it means to lead education and teacher professional development in the 21st century (Mulford,

2003). Educational systems need to support continuous professional learning in order to meet the rapid changes within a knowledge age. In this environment, educators are faced with the unique challenge of creating professional development in a time when knowledge creation "requires that individual professionals, their communities and organizations continuously surpass themselves, develop new competencies and understanding as well as produce innovations while creating new knowledge" (Paavola & Hakkarainen, 2005, p. 535). To support teacher-shared knowledge creation, educational systems need to consider the interconnectivity between idea sharing, knowledge creation, and shared meaning making that comes from a more collaborative approach to teacher professional development. The goal of my research was to develop a professional knowledge building network that would provide opportunities for me to examine how teachers construct knowledge together and develop a culture of knowledge sharing.

This study contributes to the existing body of research focused on knowledge building and current knowledge creation theories. The findings from my study may also help guide school districts with organizational structures that support the effective development of knowledge building communities for teachers and provide a better understanding of the design features and elements required in an effective knowledge building network that successfully supports sustained, collaborative teacher professional knowledge creation.

Definition of Key Terms

Collective Responsibility: Refers to the condition in which "responsibility for the success of the group effort is distributed across all the members of a knowledge building community rather than concentrated in one leader" (Scardamalia, 2002, p.2).

Epistemic Agency: Is the individual and collective responsibility for continuous professional development to advance collective knowledge (Scardamalia, 2002).

Explicit Knowledge: The objective and rational knowledge that can be expressed in words, sentences, numbers, or formulas. It includes theoretical approaches and problem solving (Nonaka & Takeuchi, 1995).

Idea Build: The integration and development of individual posted Wonderings (see below). Idea Builds represent the initial stage of shared knowledge building and provide a shared communal space where individual Knowledge Builders can plan, develop, and explore ideas together in a virtual space.

Knowledge Artefacts: Represent a compilation of social processes and shared experiences that come together to create a shared knowledge product (Sterelny, 2005).

Knowledge Builder: Individual teachers in the network are referred to as Knowledge Builders.

Knowledge Building: Is the production and continual improvement of ideas of value to a community through means that increase the likelihood that the community accomplishments will be greater than the sum of individual contributions (Scardamalia & Bereiter, 2003).

Knowledge building Community: Is any group of individuals dedicated to sharing and advancing the knowledge of the collective (Hewitt & Scardamalia, 1998). A key concept of knowledge building communities is that knowledge is constructed as the collective goal of a learning community (Gilbert & Driscoll, 2002; Scardamalia & Bereiter, 1994).

Knowledge Building Inhibitors: Identified factors that impede effective knowledge building. Knowledge Building inhibitors interrupt the flow of knowledge creation and create barriers to successful knowledge building.

Knowledge Building Principles: A set of twelve principles developed by Marlene Scardamalia (2002) that are the foundational components of knowledge building pedagogy. These 12

principles describe the key characteristics of effective knowledge building: 1). developing real ideas, 2) seeing all ideas as improvable, 3) creating opportunities for idea diversity, 4) using Rise Above idea tools, 5) creating epistemic agency, 6) supporting the development of community knowledge and collective responsibility, 7) democratizing knowledge, 8) supporting symmetric knowledge advancement, 9) creating pervasive knowledge building discourse, 10) constructively using authoritative sources for knowledge and idea improvement, 11) embedding transformative assessment within a knowledge building community, and (12) supporting the development of knowledge building discourse.

Knowledge Net: A digital tool created specifically for this research study. Knowledge Net is a knowledge building network that is designed for teachers to build, share, and develop knowledge.

Professional Learning Community: An inclusive group of people motivated by a shared-learning vision who support and work with one another, finding ways--inside and outside their immediate community—to reflect on their practice and, together, learn new and better approaches that will enhance all pupils' learning (Stoll, Bolam, McMahon, Thomas, Wallace, Greenwood, & Hawkey, 2006, p. 5).

Rise Above: Network members can develop and scaffold ideas by responding to online-posted Wonderings in Knowledge Net. Rise Above posts are intended to advance the knowledge of the knowledge building community by providing additional new information or advancing ideas from previous Wonderings.

Tacit Knowledge: Subjective and experience-based knowledge that cannot be expressed in words, sentences, numbers, or formulas, often because it is context specific. This also

includes cognitive skills such as beliefs, images, intuition, and mental odes, as well as technical skills such as teacher instructional practice and know-how (Nonaka & Takeuchi, 1995).

Wonderings: Individual online posts that contain elements of conjecture, wonder, and initial ideas for further exploration. The authored and co-authored Wonderings of individual teachers provide opportunities for teachers to explore and wrestle with current professional problems of practice.

Organization of the Dissertation

This chapter provided an overview of the problem, purpose, and context of the study. The purpose, research questions, rationale, and significance of the study were also presented, as well as the definitions of key terms. In the second chapter, a literature review focuses on key aspects of teacher professional development, online professional learning communities, effective knowledge building network design, and knowledge building theory. Also introduced is a conceptual framework for teacher-shared knowledge creation that guided the implementation, development of the digital tool and analysis of the data for this case study. The third chapter presents the methodology selected for this research study and outlines procedures for data collection and analysis. The fourth chapter presents the findings from the pilot study that was conducted to test and refine the digital tool created for the study. The fifth chapter presents the findings of the research study in relation to the conceptual model and three main themes: interactions, knowledge building, and knowledge barriers. These three themes illustrate the processes and structures required to effectively support shared knowledge creation in a networked environment. In the sixth chapter, I discuss the findings and provide a series of recommendations for supporting effective teacher professional knowledge building. Revisions to

the conceptual framework developed for the case study are discussed in detail and answers to the research questions are provided in relation to the literature and research findings. In the final chapter, I reflect on the study, share recommendations for directions for future research and conclude the dissertation.

CHAPTER TWO: LITERATURE REVIEW

This literature review draws upon multiple sources and comprises three main sections that will explore the dominant themes that emerged with regards to the development of an effective professional knowledge building network for teacher learning. The first section of this literature review presents research on teacher learning, including the important themes of effective teacher professional development, teacher discourse, and the development of teacher relational trust.

The second section of the literature review explores networks as professional learning communities and focuses on the ability of networks to support sustained collaborative inquiry and effective, shared knowledge creation. The next section of the literature review presents two knowledge creation approaches: Nonaka and Takeuchi's (1995) *Organizational Knowledge Creation Theory* and Scardamalia and Bereiter's (1994) *Knowledge Building Theory*. A summary of each model is provided and a comparative analysis of seven key commonalities that support successful knowledge creation among both models is discussed.

The final section of the literature review presents the conceptual framework developed for this case study and presents a synthesis of both knowledge creation approaches as well as a brief discussion of the various design elements that were developed in the digital tool to effectively support teacher professional knowledge building.

Teacher Professional Learning

Teacher professional learning is a complex process that involves individual and collective experiences focused on the development and improvement of teacher instructional practice and content expertise. Formal structures are often created by districts and school leaders to build collaboration among teachers, focusing on the development of shared initiatives and individual

teacher professional development opportunities. Some of these structures might include workshops and larger conferences, but they might also include smaller professional learning communities organized by grades or subject areas.

The variety of structures that comprise teacher professional learning make it difficult to determine exactly how teachers learn and what structures are most effective for supporting effective teacher learning. Traditionally, teacher professional development offered fragmented support that was narrowly focused on developing or improving individual skills and pedagogical practices. Previously, the designers of teacher professional development assumed that a separation existed between the process of knowing and doing, and therefore treated knowledge as theoretically independent of the situations where knowledge was acquired (Garet, Porter, Desimone, Birman, & Yoon, 2001). However, for school reform to be effective, Day (1999) emphasized that learning opportunities must embrace a more constructivist knowledge building model where teachers are potential learners called upon to make meaning out of their shared experiences together as a professional community.

Brown, Collins, and Duguid (1998) argued that the physical and social contexts of learning activities are integral to understanding how learning occurs among individuals. Instead of focusing on the individual as the basic unit of knowledge acquisition, they suggested that an examination of the interactions between individuals, as well as the context, become fundamental components of understanding shared knowledge development. Barab and Squire (2004) further clarified that:

> …a fundamental assumption of many learning scientists is that cognition is not a thing located within the individual thinker but is a process that is distributed across the knower,

> the environment in which knowing occurs, and the activity in which the learner participates. (p.1)

These perspectives provided a more *sociocentric view* (Soltis, 1981), where learning is the product of a group's thinking, interactions, and expressions over a period of time rather than an individual endeavour.

The teaching profession is complex and requires groups of individuals coming together to tackle professional problems that are often too large or difficult for one person to effectively handle alone. Creating structures that support the development of collective intelligence of a group of teachers provides a more comprehensive and collaborative response to teacher professional development. George Pór (1995) defined collective intelligence as "the capacity of a human community to evolve towards higher order complexity thought, problem-solving and integration through collaboration and innovation" (p. 172). Bringing teachers together to share their multiple intelligences has the possibility of evolving teacher professional learning from a focus on individual professional development to a more collaborative community that strives to develop collective wisdom that will improve the whole group's professional capital.

Gilbert and Driscoll (2002) used a case study method to investigate collaborative knowledge building in a graduate-level online course. At the end of the study, they generated four primary traits for knowledge building communities that embraced the development of collective intelligence:

1) A focus on knowledge and the advancement of knowledge rather than on tasks and projects;
2) A focus on problem solving rather than the performance of routines;

3) Dynamic adaptation in which advances made by members of the learning community change the knowledge conditions, requiring other members to readapt, resulting in continual progress; and
4) Intellectual collaboration as members pool intellectual resources, making it possible for communities to solve larger problems than can individuals or small groups (p. 60).

These primary traits support the design of a teacher professional knowledge building community that provides opportunities for teachers to share personal histories, hear multiple voices, and explore local contexts to develop and nurture collective intelligence.

Teacher discourse and learning. One of the key attributes of teacher learning is the development of a professional discourse between teachers that is directly tied to their professional practice and instructional pedagogy. Previous research by Rosebery and Warren (1998) presented the results of a four-year case study that explored the ways in which beginning classroom teachers began to internalize how to teach a complex science curriculum. They found that much of teacher knowledge and learning resided within the professional discourse teachers have with one another. In their discourse analysis of teacher professional learning communities, they discovered that teacher knowledge often transcends and moves beyond predefined terms and words. Specifically, educators see pedagogical terms as embedded within a level of discourse around a fundamental aspect of teaching or practice. For example, rather than defining what the word "assessment" means, teachers will engage in discourse around what assessment means within their classroom and how they interact and construct leaning around that term.

Not only do teachers look to discourse and language to construct meaning within their practice regarding certain terms or key ideas, but Rosebery and Warren (1998) also found that

members of a similar profession, such as teachers, rely on different expertise and experiences to develop shared meaning around their work. Their research supports the concept that the discourse that occurs between teachers is fundamental to the creation and sharing of knowledge focused on teacher practice. It is therefore essential that opportunities to support teacher professional learning must include the development of socially-constructed artefacts through discourse and language. If a professional knowledge building network is to successfully support teacher learning and knowledge creation, the technology will need to nurture teacher discourse in a way that will allow teachers to not only build and share meanings about current artefacts in a socially-constructed environment, but also provide opportunities for discourse that focuses on idea improvement and knowledge advancement.

One challenge with teacher discourse and knowledge creation within professional learning communities is that teachers may not feel comfortable engaging in critical discourse of another's practice that can move new ideas forward. Florio-Ruane and deTar (2001) discovered in their work on the design and implementation of teacher autobiographical book clubs that while teachers embrace opportunities to engage in intellectual conversations with one another about improved teacher practice, they often feel uncomfortable engaging in critical conversations with regards to other teachers. During their research, they found that the teaching profession often reinforced polite and non-judgmental group-speak with teachers that continued to encourage the privacy of teaching and the autonomy of professional development. However, successful knowledge building requires teachers to de-personalize their own teaching practices and begin to share their ideas, resources, and pedagogies through deep critical discourse that examines challenges in individual instructional practice.

While there are occasions where teachers promote the sharing of ideas, the true potential of these ideas to improve practice is often restricted because of a lack of critical discourse among teachers about their professional practice. Due to the personal nature of the teaching profession, teachers may create what Ball (1994) refers to as *style shows* where individual teachers demonstrate their own teaching style, which focuses the discourse practice on individualism within the teaching profession, rather than collaborative idea exploration. This individualism can make it difficult for teachers to engage in critical conversations because an individual teaching practice or *style* is often directly attributed to a person and their identity. Therefore, critiquing a teacher's style may be perceived as a criticism of the individual teacher. According to Ball (1994), avoiding critical conversations not only makes it difficult to develop any form of common standards regarding teaching practice, but it also hides individual struggles within teaching and removes valuable opportunities for debate around idea improvement and learning. Instead, teachers need a supported environment where they can work towards what Lord (1994) referred to as *critical colleagueship* that moves beyond professional politeness and begins to develop norms, language, and trust around the discourse of teaching. Without critical colleagueship, teachers have limited opportunities to discuss or, more importantly, improve on their own understandings about their teaching practice or the knowledge that informs that practice.

Ball and Cohen (2000) argued that what needs to occur in effective professional discourse is a shift from a *rhetoric of conclusions* around *what is* best practice to a *narrative of inquiry* that focuses on *what could be* best practice: "This shift in language will advance discourse structures from a stance of asking and debating, to a discourse of conjecture and deliberation" (p. 360). In this way, teacher discourse moves from finite discussions with concrete

and definitive answers to encouragement of more open discussions that explore pedagogical possibilities and potentials. Creating a *narrative of inquiry* is best supported in a knowledge building community where the exploration of ideas is a fundamental aspect of teacher professional discourse.

Scardamalia and Bereiter (2006) noted that critical conversations are an important component of a knowledge building environment, but there is a greater need to move the critique of shared ideas and information from transmission to transformation. A knowledge building community advances critical conversations by using them as opportunities to engage and strive towards shared understandings, and opportunities for idea improvement. Creating opportunities that develop knowledge building discourse among teachers supports the development of *critical colleagueship* and provides teachers with the skills to begin to share and create within a knowledge building environment.

With regards to a professional knowledge building network, then, discourse structures created to support teacher learning must support not only the discourse of knowledge, but also the development of knowledge through scaffolding of ideas and shared artefacts. It is also important to remember that for knowledge building discourse to thrive, a strong foundation of relational trust among participants within the knowledge building network needs to be established (Abrams, Cross, Lesser, & Leven, 2003). Perhaps the most important aspect of creating a professional knowledge building network is the development of relational trust among participants; without trust, the sharing of ideas and knowledge could easily become blocked and disrupted.

The importance of relational trust. Improving teacher practice is a difficult challenge. Darling-Hammond (1992) indicated that one of the greatest challenges of educational leaders

who want to improve teacher professional practice is breaking through the defensive routines that protect some teachers who are resistant to sharing and working collaboratively. Discussing practice for teachers is personal, and at times can lead to difficult conversations about student engagement, teacher accountability, and even teacher evaluation.

To change teacher practice, effective professional learning communities require a high level of trust. Schein (1994) argued that the concept of professional efficacy is grounded in organizational members fundamentally believing that "all people can learn, the world around them is malleable, they have the capacity to change their environment and a strong commitment to open and extensive communication will allow them to tell each other the truth" (p. 6). While online professional learning communities can offer extensive, flexible, and continual opportunities for communication and teacher collaboration, it is much more challenging to create an environment where teachers feel safe to explore, question, and compare teaching practices. Teacher collaboration holds the possibility of developing co-operation and deeper problem solving, but the important link to the success of teacher-shared knowledge building is high levels of trust.

In professional online learning communities, the nurturing of relational trust is essential, particularly because as newcomers join a virtual online community they immediately have access to an electronic record of previous discussions and various online posts. The potential for group members to misinterpret posts or post in haste can lead people to be brutally honest in the absence of face-to-face encounters. Bryk and Schneider (2002) suggested that relational trust between teachers is grounded in the respect that develops during social discourses that occur daily within school buildings and organizational communities. An important element required for the development of relational trust is respectful exchanges and genuine listening. Effective

teacher collaboration and relational trust seem to have a reciprocal relationship in professional online learning environments; we only want to share with those we trust, yet we need to be able to share to create trust.

Putnam (1993) referred to this collaborative trust as social capital and treated it as a very real asset for professional communities. Unlike traditional monetary capital, Putnam argued that the social capital of trust accumulates as groups use it, but will also diminish if unused. Personal relationships and ongoing connections among teachers are important factors that support effective knowledge sharing. A primary challenge in the development of a professional knowledge building network will be creating an environment that supports and sustains relational trust among teachers as they share and explore various ideas that focus on the improvement of teacher professional practice.

Triggs and John (2004) studied the interactions and discourse among teachers and researchers as they collaboratively developed and evaluated particularly challenging subject curriculums. Findings from their research indicated that educators build relational trust when they feel they have control and agency regarding their learning and can question current professional practices with other educators in an open non-evaluative environment. Triggs and John (2004) commented that the key to effective professional learning was the willingness of teachers to engage in knowledge transformation, where uncomfortable tensions and vulnerability among community members provided an arena to deeply explore and wrestle with authentic teacher professional problems. When educators were provided with time to develop connections and relationships that support a high level of relational trust, they moved from quick-fix solutions to professional problems and engaged in the continual pursuit of teacher best practices.

In his work on learning organizations, Senge (1990) also found that organizational members need opportunities to question their practice; he referred to this process as the creation of *mental modes* where participants look within themselves and rigorously scrutinize what they know and how they know it. It also includes engaging in "…*learningful* conversations that balance inquiry and advocacy, where people expose their own thinking effectively and make that thinking open to the influence of others" (p.9). This is an important characteristic that is required for sustaining change in teaching practice because it helps teachers move past the defensive routines described earlier that are often embedded in organizations and move towards more collegial, trusting conversations about teacher pedagogy and practice.

Online Teacher Professional Learning Communities

School districts have spent a great deal of time creating structures that separate teacher learning from teacher practice Lieberman (2000) stated that earlier professional development models focused more on teachers being developed by outside experts, rather than participating in their own development" (p. 221). In this model, school districts struggled to respond to the broad range of professional needs required by individual teachers. Teacher professional learning that pulls teachers away from their classrooms to provide them with professional training from external experts are often not sustainable and have little impact on the improvement of teacher practice (Darling-Hammond, 2005).

Shifting teacher professional development from a content transmission structure—often based on episodic events that remove the teacher from the context of the classroom—to a more collaborative focus encourages inquiry and sustained exploration of improved teacher practice. A common flaw of traditional face-to-face professional development is that it removes teachers from their practice, or focuses on what Lakoff and Johnson (2008) referred to as the *conduit*

container model. In this model, knowledge that is contained in the heads of experts is transmitted to other individual teachers. Many models of professional development for teachers still reflect this concept of teachers being pedagogical vessels attending large conferences, workshops, or division-led professional development days, where information is merely poured into them and the transference of this new information to the classroom is left up to each individual teacher. Shifting to an online model of professional learning provides opportunities for teachers to engage in ongoing and responsive professional learning.

Online professional learning communities are viewed as "emergent, self-reproducing, and frequently extend beyond, formal organizational structures, norms of behavior, communication channels, and history" (Schlager & Fusco, 2003, p,4). An important component of online professional learning communities is providing teachers with the ability to self-organize around meaningful problems of practice, where they can collectively make sense of teacher instructional practice.

Katz and Earl (2010) found that a key enabler of successful virtual professional learning communities is the ability to connect school-based teacher groups with broader school counterparts. Online professional learning communities make it possible for teachers to explore new social structures that connect them with experts outside their own school and district. The advantage of online professional learning communities is that they provide collaborative structures where a balance can be achieved between inside knowledge, including individual teacher expertise, and outside knowledge that is comprised of current research and pedagogical practices. More importantly, teachers are provided with multiple opportunities to move outside their current professional learning contexts and broaden their scope, range, and influence of shared professional practice. This is an important characteristic of professional learning because

it provides teachers with a platform where they can challenge their thinking and engage in discussions that help support the development of innovative professional practices. Teachers need these opportunities to connect with other professionals beyond their school and classroom walls to develop their own professional practice and explore new pedagogies.

Providing teachers with asynchronous digital systems that increase their ability to interact with more teachers and experts is not enough, however. Effective professional online learning needs to embrace sustainable learning opportunities for teachers that promote improved practice. A central premise outlined by Barab, MaKinster, and Scheckler (2003) with regards to an effective community of practice is that it must embrace a learning process with ongoing connections between what is learned and the context or situation where that learning is applied. For professional learning communities to improve teaching practice, persistent and sustained learning opportunities are needed rather than sporadic meetings, pre-determined days, and top-down initiatives where teachers come together. Online learning environments can provide teachers with opportunities to connect more often and sustain the learning and connections of a group of teachers by transcending the formal professional learning structures often found in school districts.

Further, online professional learning communities are responsive to the needs and contexts of individual members. Providing teachers with a space that is not constrained by time or topic allows authentic professional learning to emerge. Pre-planned professional development that is organized around divisional goals or provincial initiatives denies teachers the opportunity to determine individual areas of challenge, and provides minimal opportunity for growth and improvement. Similarly, grouping teachers by grade and subject often does not allow teachers to select meaningful topics, or establish professional learning communities that can engage in

ongoing critical conversations focused on specific pedagogical challenges. Campbell, Liberman, and Yashkina (2016) emphasized that to have a lasting impact on teacher professional practice, professional learning must be focused, rigorous, and critical. If improved professional teaching practice is the goal, then teachers should have opportunities to identify areas of struggle within their individual practice and self-organize into groups where they can be immersed in a community that is dedicated to ongoing learning and deliberation about teacher professional practice.

New and developing technologies can provide opportunities for professional learning communities to be evolving entities that move beyond conventional professional development structures found in most school districts. Regardless of the platform, effective online professional learning tools need to focus on the social processes involved in professional learning. A review of some of the most common digital tools used for professional online learning revealed that often the design of the digital environment did not effectively support the deep levels of engagement and connection needed to sustain teacher professional learning. For example, learning management systems such as Moodle, Blackboard, and D2L are designed to support course content dissemination, but do not provide a platform that can nurture and sustain ongoing collaborative discussion and inquiry. Similarly, digital platforms such as Twitter or Blogs, which effectively nurture higher levels of discussion, are limited in their ability to support collaborative knowledge building and shared resource development.

Barab, MaKinister, Moore, and Cunningham (2001) found that "An important part of a professional development structure is to offer tools that allow participants to better connect with the community and construct knowledge" (p. 75). This often requires a digital environment that is open and does not have built in administrative controls or role hierarchies that provide

different access points for different levels of members. However, providing an environment where all online members are of equal status can be a challenge for many digital environments and few digital tools can foster the development of shared knowledge building and deep idea exploration that is required in effective professional development for teachers. A more robust structure such as a network can provide a virtual space where multiple tools and features can be integrated to support sustained and ongoing collaborative discussions and the development of collective understanding.

Online Knowledge Building Networks

Technology is continually changing the way people communicate and share information. Networks and social media platforms provide individuals with loose, borderless, and flexible environments that support the continual exploration of personally meaningful ideas through a web of interconnections. Knowledge building networks provide teachers with opportunities to engage in deep meaningful learning where professional experiences are translated into sharable knowledge that is continually improved and developed (Kramer & Wells, 2005).

A knowledge building network requires teachers to develop an *enquiry habit of mind* (Earl, Katz, Elgie, Jaafar & Foster, 2006) where teachers are continually seeking and advancing shared ideas. Knowledge creation that focuses on individuals reflecting and improving on their professional practices requires an environment where teachers can share, question, and transform current knowledge and expertise into new collective knowledge. Little (2004) found that the learning and development of teacher professional practice was best achieved when teachers were provided with opportunities to collectively question ineffective teaching practices and examine new shared conceptual understandings of teaching and learning. Knowledge building networks that support the development of an enquiry habit of mind provide opportunities for teachers to

continually question, reflect on, and improve professional practice through collaborative discussions, sustained idea sharing, and collective knowledge building.

Another key aspect of an effective knowledge building network is the development of sustained discourse and collaboration. This is particularly important in shared knowledge creation where intensive interactions are required to support ongoing problem solving and the spread of ideas and innovation. To develop sustained collaborative inquiry, networks need to create a variety of contexts where meaningful issues and professional challenges can be discussed, questioned, and scaffolded to develop deeper Idea Builds. Strengthening the connectedness between teachers increases the sharing of ideas and encourages teachers to "upload their ideas and practices into the network…and download and use ideas and practices from the network for local knowledge creation and sharing" (Katz & Earl, 2010, p. 29). Also, teachers need to have access to discussion forums that nurture progressive idea inquiry and allow working theories of knowledge, professional practice, and pedagogy to organically develop in the network through the discourse and interactions of various network members. Network learning communities that support and develop sustained collaborative inquiry have the potential to facilitate shared knowledge creation, but they must support the development of the community rather than the improvement of isolated network members.

One of the key aspects of a knowledge building network is that it can create opportunities to move a learning community to a larger audience or a deeper level of understanding. A knowledge building community has the potential to move from first order changes to second order changes (Ertmer, 1999). In first order changes adjustments to current teaching practice are made in incremental phases, while often leaving the underlying beliefs that support those practices unchallenged. In second order changes, the fundamental beliefs concerning current

practice are brought to the forefront and the knowledge, understandings and contexts around teacher practice are open for discussion and exploration. According to Ertmer (1999) first order changes in a learning environment create extrinsic barriers that often impact a teacher's practice, while second order changes present intrinsic barriers such as teacher beliefs and understandings around teaching and learning. The goal of a knowledge building network is to move teacher professional development from a focus on first order changes to a more sustainable exploration of second order changes. Scardamalia and Bereiter (2006) propose that knowledge building and learning can create first order and second order learning environments. In first- order environments, learning is often asymptotic as individuals become comfortable in their routines. In second-order learning environments, learning moves to non-asymptotic learning where participants begin to move outside of their familiar routines and view ideas from multiple perspectives.

Finally, knowledge building networks rely on leaders to develop and support the ongoing pursuit of advanced idea exploration and knowledge building in the network. The focus of leadership with regards to a professional network is to develop and build a knowledge sharing culture. Rather than place these roles specifically on formal leaders, knowledge building networks require distributed leaders that support and develop knowledge sharing within teams. For a knowledge building network to be successful, leaders need to combine the expertise of other knowledge members, support and develop trust within teams, and create synergy throughout the network that seeks to innovate and improve teacher professional practice. Such leadership patterns require an expanded notion of leadership to include ongoing relationship building and foster cultural norms in the network that support sustained shared knowledge creation. Effective network leaders develop structures that support collaborative inquiry and

connect Knowledge Builders together to encourage the study and examination of teacher professional practice.

Hopkins and Jackson (2002) concluded that leadership in a network is a collective endeavour related to collaborative processes and learning. The main premise of leadership distributed in networks is to create social capital and facilitate collaboration by developing high levels of trust among teachers while supporting inclusive and ongoing collaborative knowledge building activities. Distributed leadership provides opportunities for individual teachers to occupy the numerous spaces and connections among teachers in a network. Where formal leaders create the organizational structures to support knowledge building in schools and learning communities, network leaders facilitate routines, processes, and interactions that support the initiation and development of shared knowledge creation.

Knowledge Creation Approaches

The remaining section of this literature review considers two knowledge creation approaches: Nonaka and Takeuchi's (1995) *Organizational Knowledge Creation Theory* and Scardamalia and Bereiter's (1994) *Knowledge Building Theory.* A summary of each approach will be provided as well as a comparative analysis of seven important commonalities that were identified that illustrate the key elements required in successful knowledge creation. A brief explanation is also provided that positions this study within the context of current research and theory. Finally, the conceptual framework developed for this case study is presented with an accompanying discussion of the various components of the digital tool designed for this case study.

Nonaka and Takeuchi's organizational knowledge creation theory. Nonaka and Takeuchi (1995) created the *Organizational Knowledge Creation Theory* to help describe and

explain the process of innovative knowledge creation. A central component of this model is the distinction between two kinds of knowledge: *tacit knowledge* and *explicit knowledge*. Tacit knowledge is embedded personal knowledge that involves subjective qualities such as personal beliefs and perspectives that are formed through personal experiences that often cannot easily be expressed in words. Explicit knowledge, on the other hand, is knowledge that is easily expressed and transferred from one individual to another within an organization. According to Nonaka and Takeuchi's theory, the interactions that occur between tacit and explicit knowledge serve as the fundamental building blocks for the knowledge creation process. This concept is best illustrated in the form of what is known as a *knowledge spiral*

In the knowledge spiral, there are four types of knowledge conversions: (a) socialization (tacit to tacit), (b) externalization (tacit to explicit), (c) combination (explicit to explicit), and (d) internalization (explicit to tacit). Within the knowledge spiral, knowledge initially begins with the *socialization* process where the tacit knowledge of one person is shared with another person. In this phase, knowledge transfer is active and meaning is developed through the shared experiences of individuals to form common understandings and build collegial trust within organizational groups.

The next phase of *externalization* involves the process of making tacit knowledge explicit. Individuals begin to articulate their own tacit knowledge and explore the tacit knowledge of other individual members. Within this phase, discourse is an essential component that allows individuals to share beliefs and learn how to better articulate their own thinking using feedback and reflection. This is a key phase of the knowledge spiral because a main premise in Nonaka and Takeuchi's (1995) model is that tacit knowledge is the essential knowledge required

in innovation. Therefore, converting tacit knowledge into accessible explicit knowledge is important with regards to successful knowledge creation.

In the *combination* phase, newly transformed explicit knowledge is shared and revised by organizational members to make it more usable for the organization. Finally, in the *internalization* phase, organizational members begin to internalize the explicit knowledge and convert it into tacit knowledge that can then be actualized by the organizational members. The internalization process transfers organization and group explicit knowledge back to the individual.

The model is cyclical in nature, and so the introduction of new tacit knowledge would initiate another cycle of the knowledge spiral. The strength of the *Organizational Knowledge Creation Theory* is that it addresses the complex interactions associated with improved practice and collective professional learning. Throughout the knowledge spiral, individuals are provided opportunities to create and refine the most advanced and innovative practices within their organization and work collaboratively towards bringing about meaningful changes that benefit the whole organization.

Scardamalia and Bereiter's *Knowledge Building Theory*. Scardamalia and Bereiter (1994) developed the *Knowledge Building Theory*, which focused on the collective advancement and improvement of ideas. The creation of *The Knowledge Forum* (1994) a digital tool that supports idea improvement entailed in *Knowledge Building Theory*, reinforces the essential tenet of the theory that learning communities can create a culture that "captures the natural tendency to play creatively with ideas, and expand it to the unnatural human capacity to exceed the boundaries of what is known and knowable" (p. 9). To exceed expectations and move past routines, Scardamalia and Bereiter (1994) suggested that knowledge building communities take

an inquiry stance where questions can provide an initial invitation for ideas to be put forth to activate knowledge building and idea improvement.

One of the main characteristics of a knowledge building approach is that it supports the advancement of learning by a group rather than an individual. Scardamalia and Bereiter (2006) emphasized that, in a knowledge building community, there is shift from honouring the state of knowledge that exists within an individual's mind to celebrating the contributions that a community can make together in order to advance and develop the collective knowledge of a whole organization. In a knowledge building community, ideas are viewed as *epistemic artefacts* (Sterelny, 2005) that support the fundamental belief that knowledge creation does not consist of creative individuals or exemplary individual practices, but instead is a compilation of social processes and shared experiences. In this environment, participants begin to move from knowledge transmission to shared knowledge creation as they support one another in their learning.

Seven Key Knowledge Building Principles

Both Nonaka and Takeuchi's (1995) and Scardamalia and Bereiter's (1994) knowledge creation approaches sought to explain and help us to understand the iterative and social nature of knowledge building. Each approach considered the development of knowledge and the social processes that are intertwined within the interactions and transference of knowledge from one individual to another. The following section provides a summary of seven key knowledge building commonalities that were identified in both creation approaches and are considered key elements in successful knowledge creation: 1) Knowledge creation is a community endeavour, 2) The importance of questions and questioning in knowledge creation, 3) The goal of knowledge creation is idea improvement and/or innovation, 4) Knowledge Builders play a fundamental role

in knowledge creation, 5) Interactions and discourse trigger and sustain knowledge creation, 6) Knowledge is converted and transformed into many forms and levels, and 7) Co-created Knowledge Artefacts facilitate and support knowledge creation. These seven commonalities are the foundational components of the *Conceptual Framework for the Creation of Shared Professional Knowledge* that was developed for this research study.

Knowledge creation is a community endeavour. Although each knowledge creation approach provided a different context and perspective regarding knowledge development, a main commonality is that knowledge creation is a social process that occurs within a community of knowledge creators rather than an individual endeavour for self-improvement. Paavola, Lipponen, and Hakkarainen (2004) noted that in knowledge creation approaches "…new ideas and innovations emerge *between* rather than *within* people" (p. 564). Both Nonaka and Takeuchi's (1995) *Organizational Knowledge Creation Theory* and Scardamalia and Bereiter's (1994) *Knowledge Building Theory* recognize the importance of socialization when sharing, converting, and transforming knowledge among individuals.

Knowledge creation also embraces the importance of shared problem solving and inquiry that allows individuals to come together and create new knowledge. Paavola, Lipponen, and Hakkarainen (2004) indicated that knowledge creation approaches often "…share the idea that innovation, or intelligence arises from systemic features of a whole community or organization" (p. 564). These systemic features are embedded within both knowledge creation approaches and demonstrate how the social elements and processes of knowledge creation are fundamental to successful knowledge creation. Nonaka and Takeuchi's (1995) *Organizational Knowledge Creation Theory* is based on the social processes among individuals as they convert tacit knowledge to explicit knowledge within the knowledge spiral. Whereas, Scardamalia and

Bereiter (1994) believe the real ideas and authentic problems provide opportunities for members of knowledge building communities to come together and establish socio-cognitive norms focused on sustained idea improvement.

The importance of questions and questioning in knowledge creation. The vital role of questions and questioning is demonstrated throughout both knowledge creation approaches. Both approaches acknowledge that questioning can initiate valuable interactions among Knowledge Builders that reveal weaknesses in practices or initiate idea improvements that can redefine and revise already existing practices. Scardamalia and Bereiter (1994) proposed that, for knowledge creation to occur, a shift in focus is needed from knowledge categories and topics to authentic problems that collective groups can collaboratively explore. These authentic problems allow Knowledge Builders valuable opportunities to conceptualize and create new knowledge, not just rephrase and review current static knowledge. To sustain idea improvement, Scardamalia and Bereiter (2006) maintain that knowledge building communities need to begin investing in deep inquiry that focuses on the *how* and *why q*uestions associated with specific organizational practices rather than the more simplistic *what* and *when* questions that provide only a surface understanding of problems and issues.

In the *Organizational Knowledge Creation Theory* (Nonaka & Takeuchi, 1995) questions play an important role in the effectiveness of the knowledge spiral especially when individuals begin to move into the internalization phase of knowledge creation theory. Nonaka and Takeuchi note that individuals are not passive participants with regards to the internalization of new knowledge; instead, they are active interpreters struggling to make new knowledge conform to their current context and perspective. Therefore, the ability to question discrepancies in meaning can avoid crisis or knowledge breakdowns. At the same time, using questions to continually

challenge the explicit knowledge that has been created within the organization leads to further advancement and innovation.

The use of questions and questioning in both knowledge creation models demonstrates that for an organization to learn and build knowledge together, knowledge and information cannot be viewed as a static object that is owned by an individual. Instead, knowledge is viewed as a social product that is created though an inquiry process where a group of individuals question and challenge the present state of knowledge so that together organizational members can seek to improve and advance knowledge for the betterment of the entire organization.

The goal of knowledge creation is idea improvement and/or innovation. The pursuit of innovation and idea improvement is considered a fundamental aspect of successful knowledge creation. Nonaka and Takeuchi (1995) demonstrated how providing individuals with opportunities to explore and articulate their own tacit knowledge and perspectives with other organizational members created a dynamic knowledge building environment where individual ideas and knowledge were converted to explicit collective knowledge within organizations. According to Nonaka (1994), the importance of this continual dialogue between tacit and explicit knowledge is essential to knowledge creation and, "…although ideas are formed in the minds of individuals, interactions between individuals typically play a critical role in developing these ideas" (p. 15). To increase innovativeness within an organization, ideas need to be shared and continually subjected to the interplay between tacit and explicit knowledge.

Scardamalia and Bereiter and (2006) viewed knowledge building as a social process that is focused on the continual improvement of ideas within a knowledge building community. In a knowledge building environment, Scardamalia (2002) noted that idea generation usually starts with individual members tackling authentic problems that help support idea improvement. In

successful knowledge building, individuals strive to move beyond present practices and understandings and work towards achieving something better. New ideas and contradictions become the driving force for idea improvement because they provide the initial motivation for individuals to question and transform practices within various knowledge building communities.

One of the main characteristics of a knowledge creation approach is that it supports the advancement of learning by a group or organization rather than an individual. Scardamalia and Bereiter (2006) emphasized that, in knowledge building communities, there is shift from honouring the state of knowledge that exists within an individual's mind to celebrating the contributions that a community can make together to advance and develop the collective knowledge of a whole organization. However, they also found that the "…generating of ideas appears to come naturally to people…but sustained effort to improve ideas does not" (p. 7). Therefore, to sustain continual idea improvement, ideas can no longer be viewed as individually owned, but rather as epistemic artefacts (Sterelny, 2005). These artefacts represent tools that serve to further advance and support knowledge creation. A knowledge building community that creates epistemic artefacts supports the fundamental belief that knowledge creation does not consist of creative individuals or exemplary individual practices, but instead is a compilation of social processes and shared experiences.

Common to both approaches is the over-arching goal of improving the collective understanding and knowledge of an organization rather than focusing exclusively on the growth of an individual learner. A key premise in both knowledge creation approaches is that a group of learners can reveal knowledge and ideas that were previously unknown to an individual and therefore contribute to the building of expertise that otherwise might not be possible. To this end, both approaches envision knowledge creation that focuses on the sustained collective pursuit of

idea improvement as the primary knowledge goal rather than personal learning and individual improvement.

Knowledge builders play a fundamental role in knowledge creation. The role of individuals within both knowledge creation approaches demonstrates a fundamental shift in knowledge advancement. Rather than seeing knowledge as an individual effort to improve on specific skills and expertise, the knowledge creation models illustrate the important role that individual members play within a community of knowledge creators. Each model still recognizes the important skills, expertise, and tacit knowledge that individuals bring to a knowledge community; the difference in a knowledge creation approach is that individuals share and build on the knowledge of other community members to strengthen and improve the collective knowledge of the group.

According to Nonaka and Takeuchi (1995), individual tacit knowledge initiates the knowledge spiral, where individual members work together to convert and transform their own tacit knowledge into explicit knowledge that can be shared and strengthened by the collective group. Scardamalia and Bereiter (1994) also emphasized the important role that individual Knowledge Builders play within a knowledge building community. However, Scardamalia (2002) also focused on the need for individual members to create and develop collective responsibility within a knowledge building community. *Collective cognitive responsibility* (Scardamalia, 2002) is the condition in which "…responsibility for the success of the group is distributed across all members rather than being concentrated in a leader" (p. 2). By encouraging collective cognitive responsibility, equity and agency can be developed within a knowledge building community because all members equally share ideas and information rather than individuals creating silos of knowledge and expertise that can often fracture and disrupt the

development of collective wisdom across a knowledge building community. Using knowledge building discourse, interactions between Knowledge Builders provide opportunities for knowledge to be collectively shared and improved throughout a community.

Scardamalia (2002) suggested 12 knowledge building principles that support the development of collective cognitive responsibility: 1). Developing real ideas, 2) Seeing all ideas as improvable, 3) Creating opportunities for idea diversity, 4) Using Rise Above idea tools, 5) Creating epistemic agency, 6) Supporting the development of community knowledge and collective responsibility, 7) Democratizing knowledge, 8) Supporting symmetric knowledge advancement, 9) Creating pervasive knowledge building discourse, 10) Constructively using authoritative sources for knowledge and idea improvement, 11) Embedding transformative assessment within a knowledge building community, and (12) Supporting the development of knowledge building discourse. These knowledge building principles demonstrate the important role that individual members play within the knowledge creation approach and demonstrate the need to support the discourse and interactions that occur among individual knowledge creators to successfully sustain knowledge creation.

Interactions and discourse trigger and sustain knowledge creation. The essential role interactions and discourse play in triggering and sustaining shared knowledge creation is apparent in both knowledge creation approaches. In the *Organizational Knowledge Creation Theory*, actions and interactions create and convert tacit and explicit knowledge (Nonaka & Takeuchi, 1995). Without these interactions, individual tacit knowledge would remain inaccessible to other organizational members.

Scardamalia and Bereiter (2006) also recognized the importance of interactions and discourse within a knowledge building community. Individuals engaging in knowledge building

discourse are committed to the development and improvement of ideas and knowledge sharing. According to Bereiter (2002), knowledge building discourse involves a set of three commitments that distinguish it from other types of discourse: 1) a commitment to progress, 2) a commitment to seek common understanding rather than merely agreement, and 3) a commitment to expand the base of accepted facts. These three commitments illustrate the kind of discourse and interactions that are required by individuals within a knowledge building community to support continuous idea improvement.

Knowledge is converted and transformed into many forms and levels. Another important commonality in the knowledge creation approaches is that different types and levels of knowledge are shared and converted during knowledge creation. Nonaka and Takeuchi (1995) distinguished between tacit and explicit knowledge and the transfer of these types of knowledge within the knowledge spiral. Throughout the knowledge creation process, Nonaka and Takeuchi emphasized that tacit knowledge, the highly personalized knowledge that represents individual expertise and know-how, is not easily transferrable, yet is the key to innovation. Therefore, for knowledge creation to be successful and lead to new innovative ideas, individuals need to find multiple ways to express their tacit knowledge and convert it into purposeful explicit knowledge that can be internalized by other organizational members.

Bereiter and Scardamalia (1998) also recognized that effective iterative idea improvement requires a shift in focus regarding the nature of knowledge acquisition and how knowledge is viewed within an organization. They proposed that understanding begins with a distinction between two kinds of knowledge: *knowledge about*, where individuals have declarative knowledge that is easily retrievable, and *knowledge of,* that is much more intuitive and richer in context. According to Bereiter and Scardamalia (1998), organizations need to move

towards creating and sustaining opportunities for individuals to engage in authentic knowledge of activities rather than knowledge about activities. This is because knowledge about something is limited to situations, skills, and understanding, whereas knowledge of has the potential to go deeper and connect with the real essence behind learning and knowledge creation.

For example, teachers have a great deal of expertise and knowledge about their subject area, but the more complex knowledge of teaching that subject and the conversations that can develop with other educators focusing on the knowledge of teaching have greater promise for impacting student learning. To reach this deeper level of understanding, authentic and continuous knowledge building discourse is required that engages individuals in the creation of shared epistemic artefacts (Sterelny,2005) that continually explore the knowledge of teaching.
Both knowledge creation approaches reject the perspective that knowledge is a static finite entity. Instead, each model demonstrated the movement of knowledge into different forms that exist within organizations and illustrated how knowledge is often transformed and converted by individual interactions throughout the knowledge creation process.

Co-created Knowledge Artefacts facilitate and support knowledge creation. The final commonality across both knowledge creation approaches is the important role of conceptual artefacts. In knowledge creation approaches, the focus is not on the attainment of new individual knowledge rather it is about understanding the iterative social processes of knowledge advancement that occurs continuously between individuals. In the externalization phase of their theory, Nonaka and Takeuchi (1995) noted the importance of mediating and conceptualizing knowledge artefacts where tacit knowledge becomes explicit and is shared with other members within the organization. Similarly, Bereiter and Scardamalia (1993) emphasized the mediating role that conceptual artefacts play within knowledge creation.

According to Scardamalia (2002), the strength of conceptual artefacts is their ability to encourage participants to negotiate their personal ideas with the ideas of others using shared *epistemic agency.* Scardamalia depicted epistemic agency as the process of sustaining the creation and improvement of ideas through collective contributions, where participants take cognitive responsibility for their learning. Shared epistemic agency is essential to knowledge building because it enables learners to create, build, and pursue conceptual artefacts and epistemic goals within a knowledge building community.

In both approaches, the conceptualization of knowledge and the mediating role of conceptual artefacts play important roles in knowledge creation. Conceptual artefacts provide a shared focus for organizational members; they also initiate the important interactions and discourse necessary for collective knowledge advancement and improvement. During the knowledge creation process, individuals need to be provided with the opportunity to share and create conceptual objects that collectively improve their professional practice, while also improving the organization.

Positioning the Research

Through a review of the literature on teacher professional development, online professional learning, the creation of knowledge building networks, and a review of two knowledge creation theories, two important gaps were identified in the research that this study addresses.

First, both knowledge creation theories presented in this literature review focus on different contexts regarding knowledge creation. The research of Scardamalia and Bereiter (1994) was dedicated to the development of knowledge building as an educational approach that engages students in pervasive idea exploration and collective knowledge advancement. The

research of Nonaka and Takeuchi (1995) focused on the development of *Organizational Knowledge Creation Theory* with relation to organizational knowledge management and innovation. While both theories were integrated into this study, neither theory looked specifically at how teachers build and share knowledge within a networked environment. An identified gap within the current research literature is the specific examination and study of teacher-shared knowledge building with respect to professional learning and improved professional practice.

Second, few digital tools are available that are specifically designed to support sustained and responsive teacher professional knowledge building. Throughout my review of current research and digital tools, I found examples of network systems that support knowledge dissemination through the codification and storage of knowledge artefacts, but I have yet to find a network platform that focuses on the Alberta curriculum and reflects current knowledge creation theory.

Although many of the digital tools I reviewed included various features that play a role in knowledge building, I felt that in order to accurately examine teacher-shared knowledge creation in a networked environment, I would need to design a tool that I knew was aligned to current theory and research. The ability to create a network where the connections and interactions of teachers can be closely analyzed for common patterns, interactions, and individual relationships provided a unique opportunity to examine the ways that teachers build and share their professional knowledge and what inhibitors may impact successful knowledge creation. The digital tool I developed, Knowledge Net, is aligned with the conceptual framework created for this research study and was customized to support the key theoretical principles identified within both knowledge creation theories.

Conceptual Framework for the Creation of Shared Professional Knowledge and Software Design Features

This section of the literature review presents the conceptual framework that I developed for this study that includes a synthesis of the two knowledge creation approaches outlined previously in this literature review as well as the seven knowledge building commonalities. It also introduces the digital tool and software designed to support this research study.

One factor that is not explicitly explored by either knowledge creation approaches is a more in-depth analysis of how knowledge creation occurs within a teacher professional online learning environment. To create a networked environment that can support effective teacher knowledge building, research is required that can explore what types of interactions sustain and build knowledge and what kinds of social processes are involved in the mediation of conceptual artefacts. Without this information, digital tools that are constructed to support teacher professional learning may not be adequate for sustained knowledge creation and idea improvement. Therefore, the *Conceptual Framework for the Creation of Shared Professional Knowledge* presented in Figure 1 synthesizes elements from both knowledge creation approaches and the seven knowledge building commonalities to illustrate how a professional knowledge building network will support the continuous advancement of idea improvement, while also supporting knowledge building discourse and the mediation of shared knowledge artefacts.

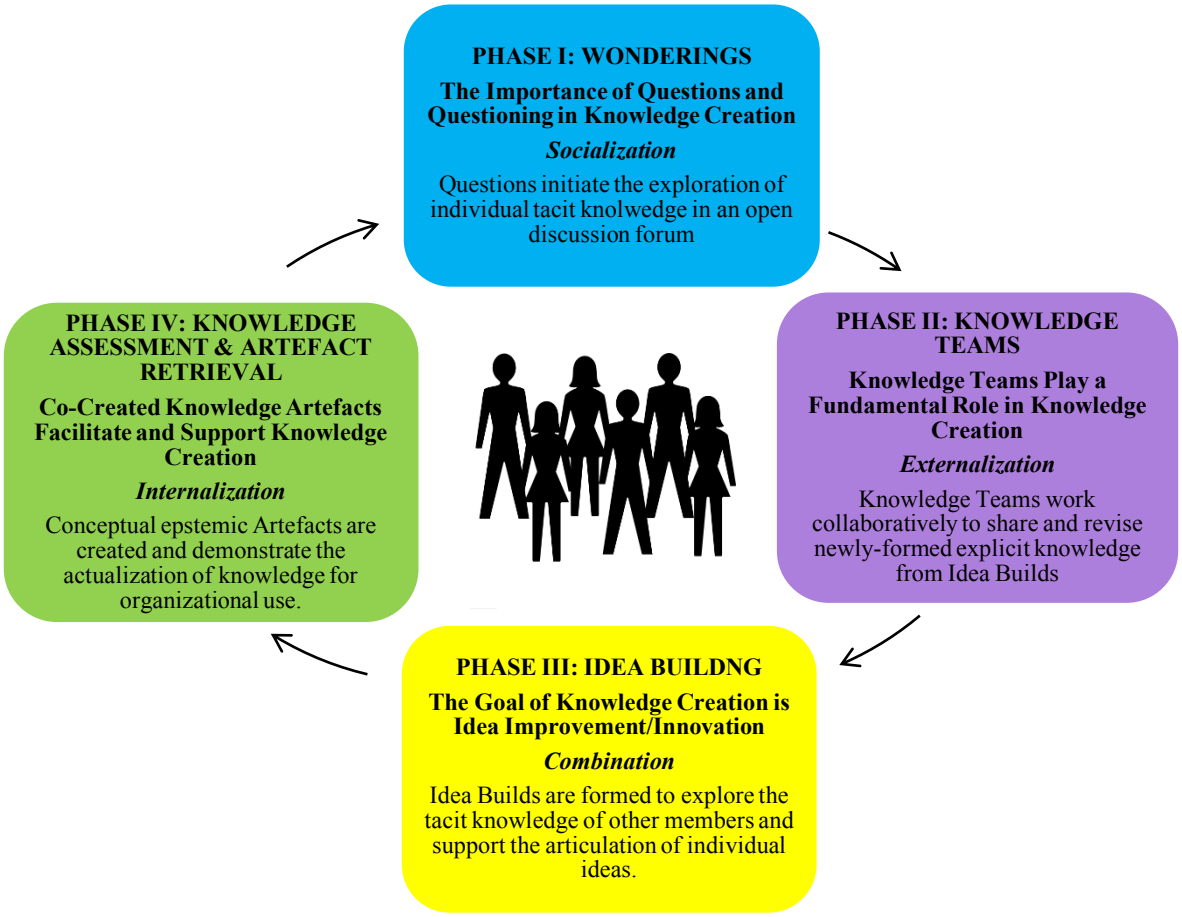

Figure 1. Conceptual Framework for the Creation of Shared Professional Knowledge.

The conceptual framework presents four phases of knowledge creation and provides an in-depth look at the roles, interactions, and artefacts that are developed during shared knowledge creation. The framework seeks to explain how knowledge building is initiated in the network and developed by teams of teachers as they collaboratively explore and build on shared ideas. The framework also indicates the four components of knowledge conversion represented in the knowledge spiral (Nonaka & Takeuchi, 1995) and outlines the key knowledge building activities associated with each of the four phases. The conceptual framework is comprised of these four interrelated phases of knowledge creation, which informed the design of the digital tool for this case study and became the key components of the network environment. To effectively support

shared knowledge creation, the digital tool needed to represent knowledge not as a static object, but as an entity created through the social processes and interactions of many individuals. Therefore, the digital tool did not seek to simply store and disseminate resources and information created by individuals in the network; instead, it focused on providing opportunities for the collective improvement and advancement of shared ideas using inquiry and knowledge building discourse. In order to be effective, the knowledge building tools created in the network supported the seven key commonalities that were discovered within the literature review: (1) Knowledge creation as a social process; (2) The importance of questions and questioning within the knowledge creation process; (3) The need to continually pursue innovation and idea improvement; (4) The integral role individuals play in knowledge creation; (5) Interactions and discourse trigger and sustain knowledge creation; (6) The mediating role of conceptual artefacts; and (7) Recognition of different forms of collaborative knowledge.

The last section of this literature review discusses the development of the network tool, Knowledge Net, as well as the four key phases developed in the conceptual framework and the implications for the design and development of the digital tool created for this study.

Knowledge Net is the prototype that has been developed as the knowledge building network tool that will be used within this research study. What distinguishes Knowledge Net from an online professional community is the manner in which knowledge is built, shared and developed by participants within a networked learning community. Rather than viewing knowledge as something that can be stored and disseminated by individuals within an online environment, Knowledge Net seeks to create, improve and advance knowledge collectively through the use of idea improvement, inquiry and critical conversations. In order to be effective, Knowledge Net was continually refined throughout the case study as participants began to

understand what knowledge building tools were needed to support authentic knowledge creation in a networked environment.

In a knowledge building network, discourse results in more than the sharing and transmission of information through threaded discussions. Knowledge building discourse supports the rich inter-textual discussions participants have around idea improvement. Therefore, knowledge networks need to support a distributed model where information is freely distributed across a networked environment, without having to pass through a central authority. Scardamalia and Bereiter (2003) suggest that knowledge building networks need to support a wide-area configuration that presents a communal database that is open to all participants at all levels so that knowledge building is not bounded by built in administrative controls or top-down hierarchical communication and dissemination structures. A networked model that uses technology to structure interaction and knowledge creation needs to support the open accessibility of information and knowledge. Developers of knowledge networks will need to resist the temptation to control or fragment knowledge within closed databases or secure firewalls as these can often block access to continual learning opportunities for teachers and inhibit knowledge sharing within the network.

Knowledge Net was therefore designed to support and open environment that is not based on hierarchical levels of knowledge and information. Instead of defining roles within a virtual community Knowledge Net supports open entry, thus allowing the community to become the driving force for sustaining knowledge advancement and idea improvement. In the initial design and development of Knowledge Net I made sure that the network supported the decentralization of online roles and hierarchies because I wanted to embrace the concept that those with more knowledge in a particular area do not stand alone; instead they support and infuse this knowledge

into the collective community. At the same time, those members with limited knowledge in certain areas can provide direction by questioning and seeking clarification regarding ideas and their interconnection to other areas of knowledge. The design of Knowledge Net provided a unique platform for teacher sharing and knowledge building because it was open and flexible. When participants entered Knowledge Net they were immediately introduced to Knowledge Net's landing page, which provided a visual image of a knowledge building factory to help guide users through the various areas of the network (see Figure 2).

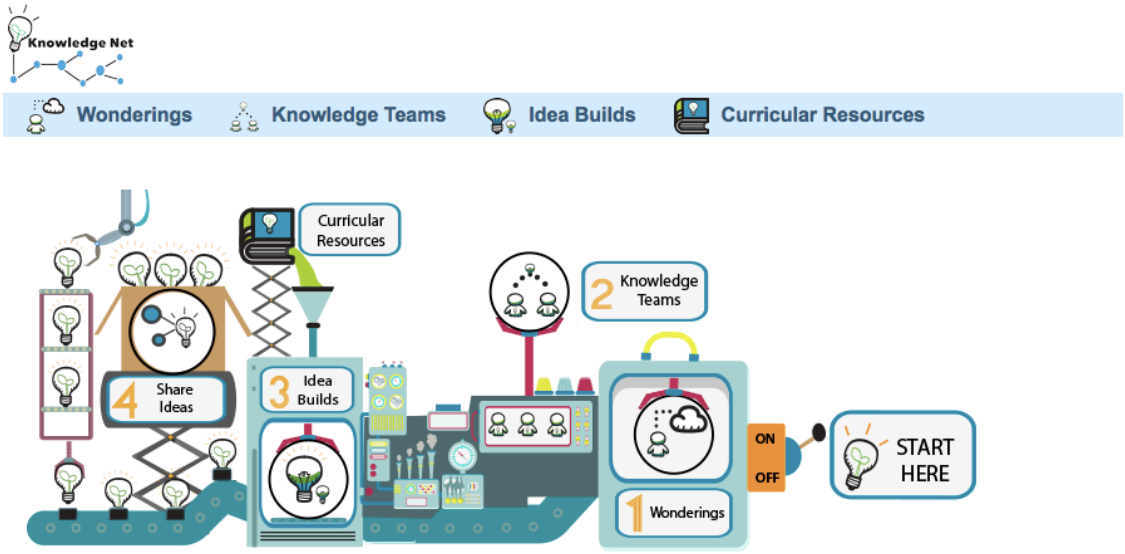

Figure 2. Knowledge Net Landing Page.

In order for a knowledge building network to be successful there needs to be a collective commitment to advance understanding rather than to display individual wisdom. Although no medium can be culturally neutral, I wanted Knowledge Net to create opportunities for diversity and interplay with ideas within a variety of discourse mediums that resisted formalizing and categorizing knowledge.

Wonderings: The importance of questions in knowledge creation. In a knowledge building network, discourse focuses on problem solving and inquiry rather than topics and subjects. Discussion threads and forums should seek to engage participants in questions and questioning with regards to their professional practice. As participants engage in knowledge building, opportunities should be provided for individuals to explore and face challenges within their own teaching practice. By exploring the interrelatedness of ideas through questioning techniques, Knowledge Net supported participant engagement in a manner that moved away from finite solutions and knowledge retrieval to an increasing focus on inquiry and shared problem solving.

Teachers began their knowledge journey In Knowledge Net by posting an inquiry question (Wondering) in the Wonderings Discussion Forum. These questions were often focused on a specific teacher need or an initial question concerning a current teacher issue or challenge related to pedagogy. A fundamental requirement of an effective knowledge-building network is the support of multiple forms of discourse. The research of Scardamalia and Bereiter (1994) indicated that there are three distinct characteristics needed to support knowledge building discourse: (a) focus on problems; (b) decentralized, open knowledge environments that support collective understanding, and (c) productive interaction within a knowledge building community. In order to support idea diversity and knowledge advancement Knowledge Net was designed to support the multi-faceted interactions that teachers required in order to effectively engage in sustained knowledge building discourse.

In a knowledge building network, discourse is focused on problem solving and inquiry rather than topics and subjects. Discussion threads and forums should seek to engage participants in the sharing of ideas, improving upon those ideas and expanding the same ideas into other

areas of knowledge creation. In Knowledge Net teachers have the opportunity to post Wonderings that focus on pedagogical issues within their own practice. When teachers access the Wonderings Discussion Forum they can post issues or challenges they are facing in teaching, present questions or queries to individual members, or present a topic for the general discussion.

The Wonderings Discussion Forum was an open forum where all network members could see the various posted Wonderings of the knowledge building community. The Wonderings that were posted in the network could be tracked by inquiry area or specific Knowledge Builder. These search features allowed other network members to easily organize and find previously posted Wonderings. A key feature in the Wonderings Discussion Forum, was the ability of network users to build and scaffold Wonderings by making them *sticky* in the network. The *sticky* feature is a toggle bar that network members used to scaffold Wonderings and move them into a Knowledge Team for further idea development and shared knowledge creation. Figure 3 illustrates the collaborative *Sticky Toggle Bar* of the My Wonderings inquiry forum and provides a demonstration of the features available to teachers as they posted a Wondering.

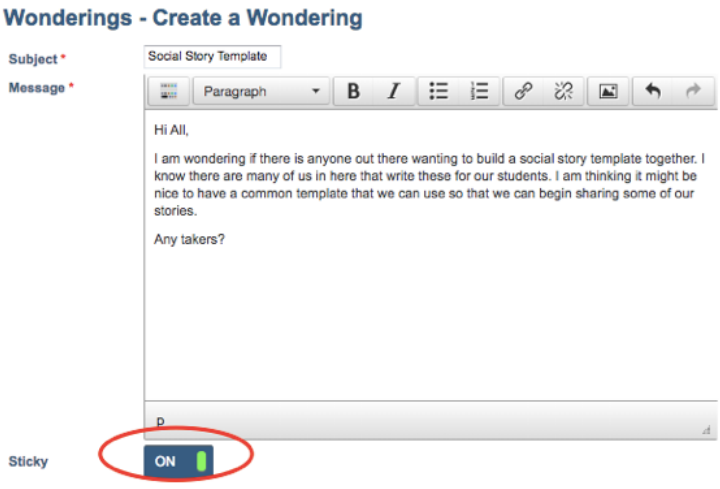

Figure 3. Wonderings Template and Sticky Toggle Bar for Scaffolding a Wondering.

As participants track and explore Wonderings within Knowledge Net, they can choose to use the rise above feature of the *Sticky Toggle Bar* in Knowledge Net to scaffold a Wondering into a Knowledge Team. Wonderings of interest were selected by participants and moved into Knowledge Teams using the *Sticky Toggle Bar* where groups of Knowledge Builders could then work together to initiate shared knowledge construction.

As participants engage in knowledge building and idea sharing there needs to be opportunities for them to explore and face challenges within their own teaching practice. By exploring the interrelatedness of ideas, Knowledge Net supported participant engagement that moved away from finite solutions and knowledge retrieval within a networked environment, to an increasing focus on inquiry and shared problem solving.

Knowledge Teams: Knowledge builders play a fundamental role in knowledge creation. Knowledge creation approaches view epistemic agency as being a shared endeavour that lives within the collaborative interactions and shared artefacts of a knowledge building community. Shared epistemic agency is essential to knowledge building because it enables learners to create, build, and pursue collectively shared epistemic goals. According to Schwartz and Okita (2004) shared epistemic agency is not a characteristic, but an emerging, recursive, and gradual process that is influenced by individual input and interactions between peers and a Knowledge Artefact that is constantly altered by feedback and the shared epistemic agency of the group.

Knowledge Net provided opportunities for teachers to form Knowledge Teams where the sharing of ideas and epistemic artefacts were developed using a variety of knowledge building tools. Shared epistemic agency as outlined by Scardamalia and Bereiter (2003) was supported through the development of Knowledge Teams, where individual Knowledge Builders

continually improved ideas together within a collaborative space. Scardamalia (2002) envisioned a knowledge-building environment where participants could negotiate their personal ideas with the ideas of others. Within this view, shared epistemic agency is essential to knowledge building because it enables learners to create, build and pursue collectively shared epistemic goals. Knowledge Net nurtures the growth of epistemic agency through the development of Knowledge Teams, where knowledge members can continually improve ideas together within a collaborative space. Figure 4 is a view of the Knowledge Teams window in Knowledge Net, which illustrates the self-organizing features of a Knowledge Net, which allows individual network users to view and join all Knowledge Teams in the network.

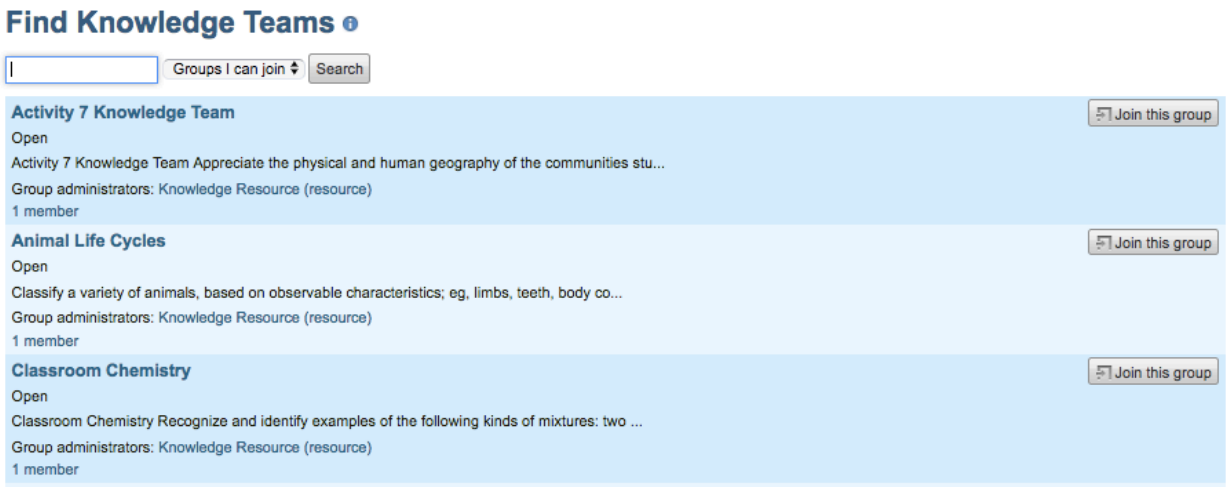

Figure 4. Knowledge Teams Window.

Each Knowledge Team also has a specific dedicated space to build and share ideas. The *Knowledge Team Palette* provides a space for groups of teachers to post Team Wonderings in a specific Team Wonderings Discussion Forum, as well as see all members within a Knowledge Team. The *Knowledge Team Palette* also provides Knowledge Teams with an area to store team

files, create Idea Builds and scaffold and share Idea Builds using the Idea Collections feature (see Figure 5).

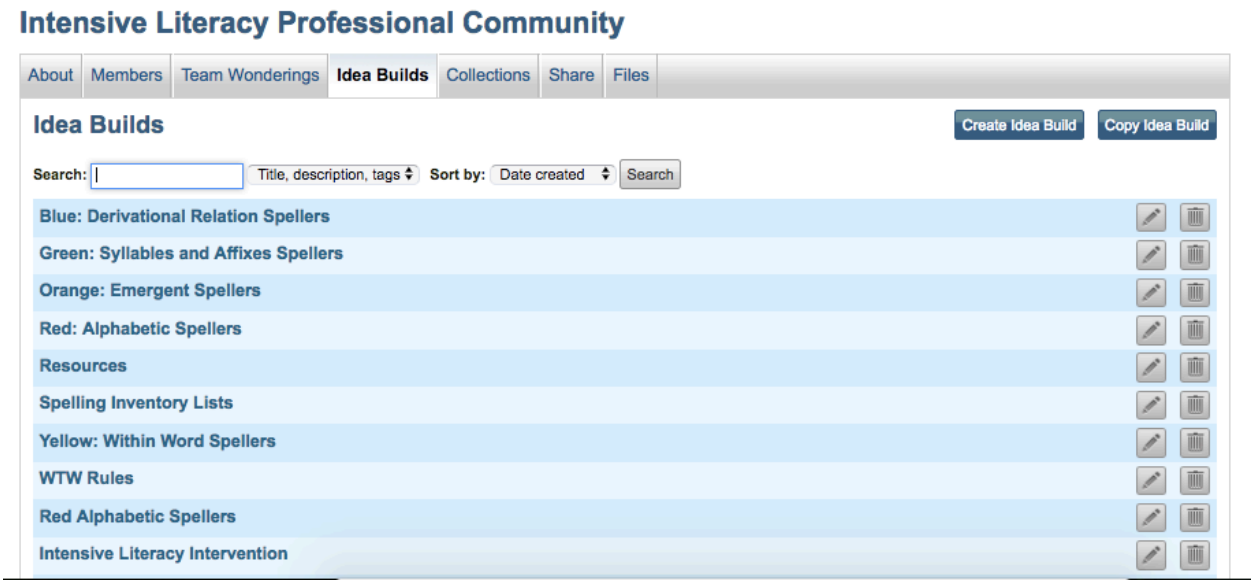

Figure 5. Knowledge Team Palette with Associated Knowledge Team Toolbar

Also, Knowledge Net allowed open invitations for members to freely join Idea Builds and contribute to discussion forums and Knowledge Teams. The open platforms within Knowledge Net provided greater capacity for participants to share and converse across subjects and schools without feeling that they must remain aligned to predetermined groups and conversations.

Through the use of Knowledge Teams, the network is able to provide a digital environment for teachers to engage in critical conversations and co-construct knowledge around shared ideas, while also providing various tools that assist with team organization and shared artifact creation

Idea Building: The goal of knowledge creation is idea improvement and/or innovation. Continuous idea improvement is needed for the advancement of knowledge. In a knowledge building network, opportunities should be available for users to compare, combine, and improve upon ideas that are created by other participants. As shared Knowledge Builders, participants will need to see the origins of ideas and how they may change, adapt, grow, and connect to other ideas. This level of idea diversity is fundamental for shared knowledge creation because it provides an environment where the unknowable can be explored and developed. Knowledge Net supports the concept of idea diversity by creating structures that allowed participants to post, link, and scaffold their ideas within a knowledge building community. For example, the Idea Builds in Knowledge Net provided individual teachers with a flexible environment where multiple ideas could be connected and collaboratively developed by groups of teachers. This provided opportunities for idea improvement and the advancement of sustained collective knowledge building.

Continual idea improvement is needed for the advancement of knowledge in a knowledge building network. In order to support shared knowledge creation there needs to be opportunities for users to compare, combine and improve upon ideas that are created by other participants. As shared Knowledge Builders, participants will need to see the origins of ideas and how they may change, adapt, grow and connect to other ideas. For true idea diversity to exist, knowledge networks need to support a variety of formats for idea construction.

Knowledge Net supports the concept of idea diversity by providing specialized knowledge building tools to network users that allow them to freely share, build and connect ideas, as well as scaffold knowledge so that it can be easily shared with other members of the network. In this way, idea enhancement can contribute to advancing the collective knowledge of

a community. The *Idea Building Palette* in Knowledge Net provides an innovative space where individuals can engage in idea improvement using knowledge building tools that allow users to create and link their ideas to multiple formats such as text, video, image, hyperlink and sound file. These various knowledge building tools can be seen in the left-hand toolbar of Figure 6.

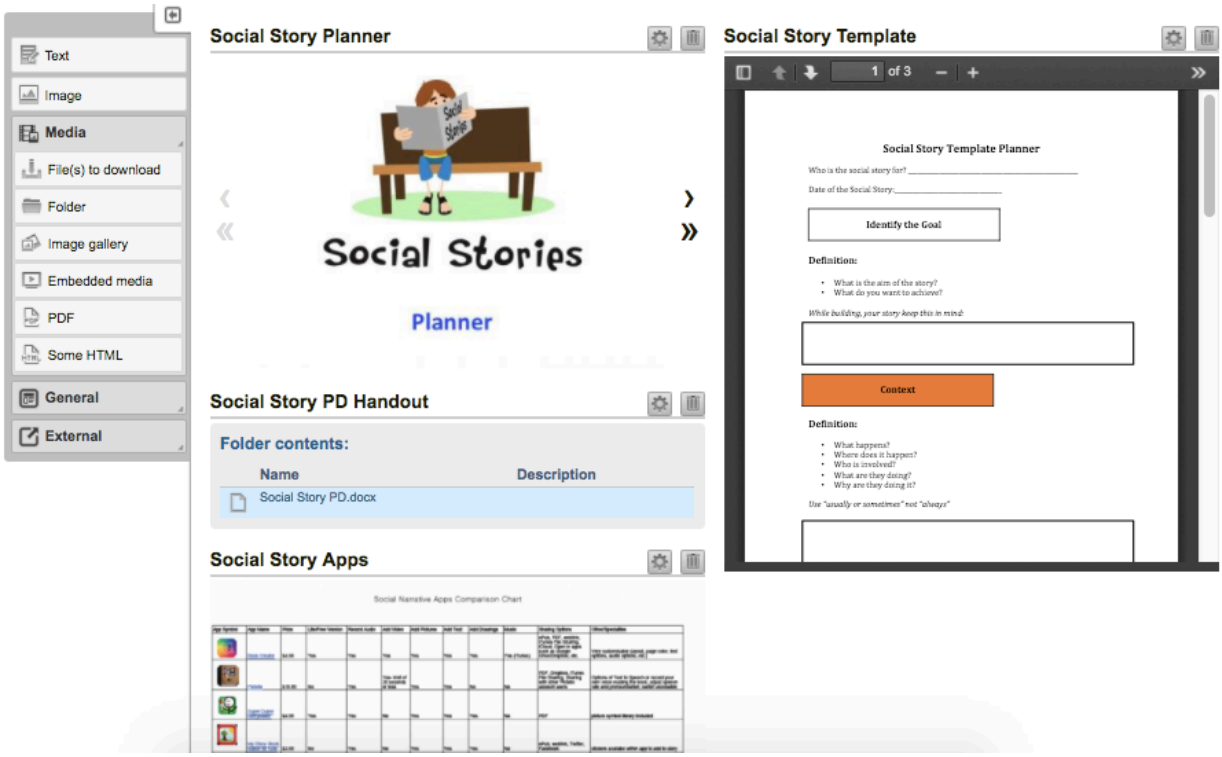

Figure 6. Idea Building Palette and Associated Idea Build Toolbar.

As participants engage in idea sharing they have access to a variety of digital formats and layout features to customize their Idea Builds. The *Idea Building Palette* has been developed to meet the changing and complex needs within a knowledge building community. As ideas are generated, each participant can review their own ideas, connect their ideas to other members within the network or engage in conversations around a central idea or Idea Build. The platform that was developed for idea diversity within Knowledge Net is flexible and customizable to

support a variety of user needs within the network and allows individuals to create ideas in multiple formats, while also supporting the evolution of ideas over an extended period of time. Through the use of idea scaffolding and multiple views, members can easily contribute to advancing the collective knowledge of a community.

Knowledge assessment and artefact retrieval: Co-created Knowledge Artefacts facilitate and support knowledge creation. Scardamalia (2002) suggested that within effective knowledge building environments, individuals negotiate their personal ideas with the ideas of others through shared conceptual artefacts. Knowledge Net supported the development of collaborative knowledge creation by allowing Knowledge Builders multiple opportunities to create, link, build, and share knowledge objects. The goal throughout the development of a Knowledge Artefact was to support the complex interactions and discourse associated with effective shared knowledge building. As members developed ideas with their Knowledge Teams, the Knowledge Artefacts they created became a representation of the collective knowledge of the group. These Knowledge Artefacts were placed into a Shared Knowledge Artefact Repository for other members to access and evaluate.

Chapter Summary

This literature review presented three key sections related to the development of a teacher professional knowledge building network. The first section focused on literature and research concerning teacher learning and professional development. The second section looked at professional online learning and knowledge networks to further develop the components and features required in an effective networking tool. The final section presented two knowledge creation approaches and a detailed discussion of the key knowledge building principles needed in an effective knowledge building network. Finally, the conceptual framework developed for this

study was presented with a detailed discussion of a technological tool developed for this research study. The next chapter presents the methodological approach and discusses the data collection and analysis methods that were utilized.

CHAPTER THREE: RESEARCH METHODOLOGY

The purpose of this study was to create a professional knowledge building network for teachers, and to explore and better understand the conditions, interactions, and processes of shared knowledge creation. In this chapter, a description of the study is provided along with a rationale for case study research. The unit of analysis is identified and the population sample is presented along with the data sources, a detailed data collection plan, and the methods of data analysis. Finally, the integrity of the study is discussed and issues related to research trustworthiness and ethics are considered. The chapter concludes with a description of the limitations and delimitations of the study and a final chapter summary.

A Rationale for Case Study Research

To explore the complex phenomena of knowledge building, a single case study design was selected. Case study is a unique qualitative research methodology that includes a variety of diverse paradigms and methods. Researchers such as Lincoln and Denzin (2003) situated case study research within the qualitative field of research methodologies. Yet, case study research can be viewed through many lenses, depending on the method of inquiry and the context. This variation of case study research can best be illustrated by comparing two distinct approaches to case study research: post-positivism as reflected in the work of Yin (2014) and the constructivist approach adopted by Stake (1995). An examination of both case study approaches provides a clearer picture of the positioning of this case study.

Post-positivism. The post-positivist paradigm employs a deterministic philosophy, where causes determine the effects and outcomes of the objects being studied. Therefore, the problems being studied by post-positivists rely on the identification and assessment of the causes that influence or determine specific outcomes. In a post-positivist paradigm, knowledge is developed

through observations and measurements of an objective reality; when studying human behaviour, numeric measurements of various observations become an essential component of post-positivism.

A post-positivist perspective with regards to case study aligns with the scientific method of inquiry where a researcher often starts with a clear theory or a set of theoretical propositions and then collects and analyzes data to corroborate that theory (Creswell, 2014). The case study approach of Yin (2014) relies on post-positivist methods when conducting case study research. According to Yin, case study research is defined as "…an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (p.16). Yin's case study approach begins with the testing of current theoretical propositions that emerge through a review of literature and research. He follows a post-positivist stance that data and research findings should either seek to clarify and corroborate the initial theoretical propositions or suggest revisions for further areas of study.

Understanding that knowledge building is a complex phenomenon, this case study seeks to test current theoretical propositions to better understand the process of shared knowledge creation among teachers. Following Yin's approach, I developed a conceptual framework informed by current knowledge creation theory. This framework was used to guide the implementation and analysis of the case study.

Yin (2014) also outlined five rationales for the use of a single case study and two of these rationales are supported by this research. First, this single case study is a *critical case* because it provides meaningful contributions that add to the development of knowledge creation theories. The underlying theoretical propositions outlined in each of the four phases of the conceptual

model are based on knowledge building principles tested throughout the study and used to confirm, challenge, and extend current understanding of knowledge building.

Second, this case study is also an example of a *common case* because it presented a social phenomenon that captured an everyday situation. Studying shared knowledge building of teachers encompassed social processes and structures that were common within professional learning communities.

Yin (2014) also suggested that a single case study is well-suited to represent critical cases that can test a well-formulated theory. In a single case study, the case is not an end to itself, but rather provides an opportunity to further understanding of the phenomena being studied. A single case can also be used to provide a new set of explanations that better clarify the phenomena being studied. For this case study, Yin's perspective provided a research design that supported the testing of the *Conceptual Framework for the Creation of Shared Professional Knowledge* that was presented earlier within the literature review chapter, while also providing opportunities for the research findings to contribute to a better understanding of the knowledge building behaviours of teachers within a networked environment.

Constructivism. A constructivist paradigm holds that reality is relative and dependent upon individual interpretations and understanding of the world. Constructivists believe that individuals develop their own subjective meanings of various experiences and contexts. In a constructivist paradigm, the goal of research is not to narrow and categorize experiences or contexts, but rather to focus on the broad complexities of individual views and experiences as they construct meaning from a variety of situations.

Constructivist researchers seek to develop theory by positioning themselves in the research and observing and interpreting individual interactions and social constructions of

different social contexts. Constructivists assume that meaning is developed through interactions and social processes. Unlike post-positivists, who focus on deductive reasoning when studying different phenomena, constructivist researchers do work that is largely inductive, generating meaning and theory from the data and observations gathered in the research field.

Robert Stake (1995) observed that "…as a form of research, case study is defined by interest in individual cases, not by the methods of inquiry used" (p. 435). Using a constructivist approach, Stake (1995) advocated for an inductive design where researchers immerse themselves in the data collection process. As the research progresses, patterns, categories, and theories merge through the data-gathering process. Stake finds that research questions are not pre-determined and explored, but rather can reformulate and emerge during the research process. In this context, theory is not the predominant tool guiding research and investigation, instead, theory is developed though intensive research and ongoing investigation.

For this case study, I felt that I needed to integrate the inductive processes with regards to data collection developed by Stake with a more prescriptive post-positivist approach for investigating the complex phenomena of knowledge building developed by Yin (2014). Using current theory to develop a conceptual framework for the case study provided a clear pathway for the research and highlighted the key areas where data should be collected and how the data would best be analyzed.

However, while I believe that theory helped structure and align my case study, I also utilized inductive reasoning similar to Stake's case study approach to interpret and explain my research findings. According to Stake (1995), "…good case study is patient, reflective, willing to see another view of the case" (p. 12). During the course of this research, I found I needed a paradigm that was positioned between the post-positivist approach and the constructivist

approach so that I had the flexibility to use deductive reasoning with regards to theoretical propositions and also inductive reasoning when interpreting, comparing, and advancing current theory.

Challenges of Case Study Research

Early conceptual views of case studies suggested that findings were only valuable if the cases themselves were directly linked with clearly aligned hypotheses. According to Dogan and Pelassy (1990), "…one can validly explain a particular case only on the basis of general hypotheses. All the rest is uncontrollable and so of no use" (p. 121). This premise leads to the first common misunderstanding identified by Flyvbjerg (2006), which is theoretical (context-independent) knowledge is more valuable than practical (context-dependent) knowledge.

Flyvbjerg (2006) argued that the development of individualized expertise and specialized skills was reached only through a person's individual experiences and unique contexts. To understand practical knowledge, a researcher must immerse themselves in the contexts and real-life situations of their participants. Reducing these personalized experiences to a set of hypotheses, or only valuing external rule-based knowledge when studying complex phenomena, often does not capture the subtle nuances and more complex experiences needed to truly understand and develop robust theories. One of the advantages of case study research is its ability to add to our understanding of various social phenomena through rich and thick descriptions (Geertz, 1973) while still maintaining the integrity of a robust study.

As a methodological approach, case study research has also sometimes been discounted because confusion exists between case study as a methodology and case study as a teaching method. Yin (2014) clarified that the use of case studies in teaching often requires that revisions or alterations are made to the case study content to meet specific needs. Case study as a

methodology, on the other hand, requires a researcher to follow clear protocols for data collection, analysis, and interpretation to ensure that the findings of the research are valid and accurate.

To increase the reliability of case study research, Yin (2014) emphasized the need for a case study protocol that provides a detailed plan for data collection procedures, as well as maintenance of a chain of evidence that creates a clear path between the research questions, the data collection procedures, and the findings within the study. Providing a case study protocol with an evidentiary process that can be replicated by others addresses concerns of researcher bias and formalizes the methodological processes associated with a case study.

Another criticism of case study research is the inability to generalize findings from a single case study. Critics of case study research question the validity of research that cannot be generalized to a larger population or different contexts. The inability to replicate findings and results statistically often brings into question the significance of case study findings. However, Yin (2014) suggested that theoretical propositions can be used to support analytical generalizations. When considering analytic generalizations, Yin (2014) asserted that the aim "…is still to generalize to these concrete situations and not just to contribute to abstract theory building" (p. 47). The testing of current theory within case study design provides opportunities to corroborate theoretical principles and advance and extend new concepts to various concrete situations.

Ensuring Quality Case Study Research

In response to the concerns and criticisms of case study research, I used a conceptual framework based on theoretical propositions to guide the implementation of the research design.

The conceptual framework provided a structure for the collection of data and assisted in the analysis and presentation of research findings.

Often in case study research, the final interpretations require a variety of data sources to clearly illustrate the intricacies and complexities of the social phenomena being studied. Case study research also allows for a mix of qualitative and quantitative research methods, permitting identification of greater causal links between a variety of data sources while also providing opportunities to explore data using objective and subjective methods. Given that this was a single case study, a convergence of data from multiple sources using various perspectives was analyzed to increase confidence in the research findings.

Research Questions

This single case study sought to answer the following research questions:

1. How can the development of an online knowledge building network influence teacher-shared knowledge creation?
    a. How do teachers build and share knowledge in a networked environment?
    b. How do the connections between teachers impact shared knowledge creation?
    d. What knowledge building barriers impact a networked environment?
    c. What types of features are required to create an effective knowledge building network?

Unit of Analysis

A key component of case study research is defining the unit of analysis that will be the basis for data collection and investigations. For this case study, knowledge was viewed not as a static object, but rather a product that was created through a mediated process of various interactions and exchanges among Knowledge Builders.

Examining the individual knowledge contributions and interactions related to the social context of knowledge building was the focus of this research study. Therefore, the primary unit of analysis for this case study was the knowledge building behaviours and interactions of teachers as they developed shared knowledge in a networked environment. The tools and features that were developed in the network were also examined to determine their ability to effectively support shared knowledge creation.

Population and Sampling

The participants for this case study were selected from teachers in a small rural Alberta school division. A brief introduction to the research was provided at a division-wide professional learning day. After the presentation, a Microsoft PowerPoint presentation was created and shared on the division professional learning website. It included an open invitation for any teacher within the district to join the study. Participant selection was closed after a two-week period and 50 teachers consented to become the main participants for the case study.

Pilot Study

To test the prototype tool created for the research study a pilot study was conducted for a six-month period. Within the initial research invitation period, teachers were asked if they would be interested in participating in a pilot study. Of the 50 participants who were selected, 20 agreed to join the pilot study and provide feedback on the effectiveness of the digital tool. A full description of the pilot study and its findings can be found in Chapter Four of this research study.

Methods of Data Collection

The data collection for the case study followed a cyclical process that aligned with the four phases of knowledge creation represented in the conceptual framework. Because knowledge creation is iterative in nature, similar data was collected through all four phases to demonstrate

how teachers created and shared knowledge in the network. Figure 7 outlines the series of data sources that were collected for each phase of the conceptual framework.

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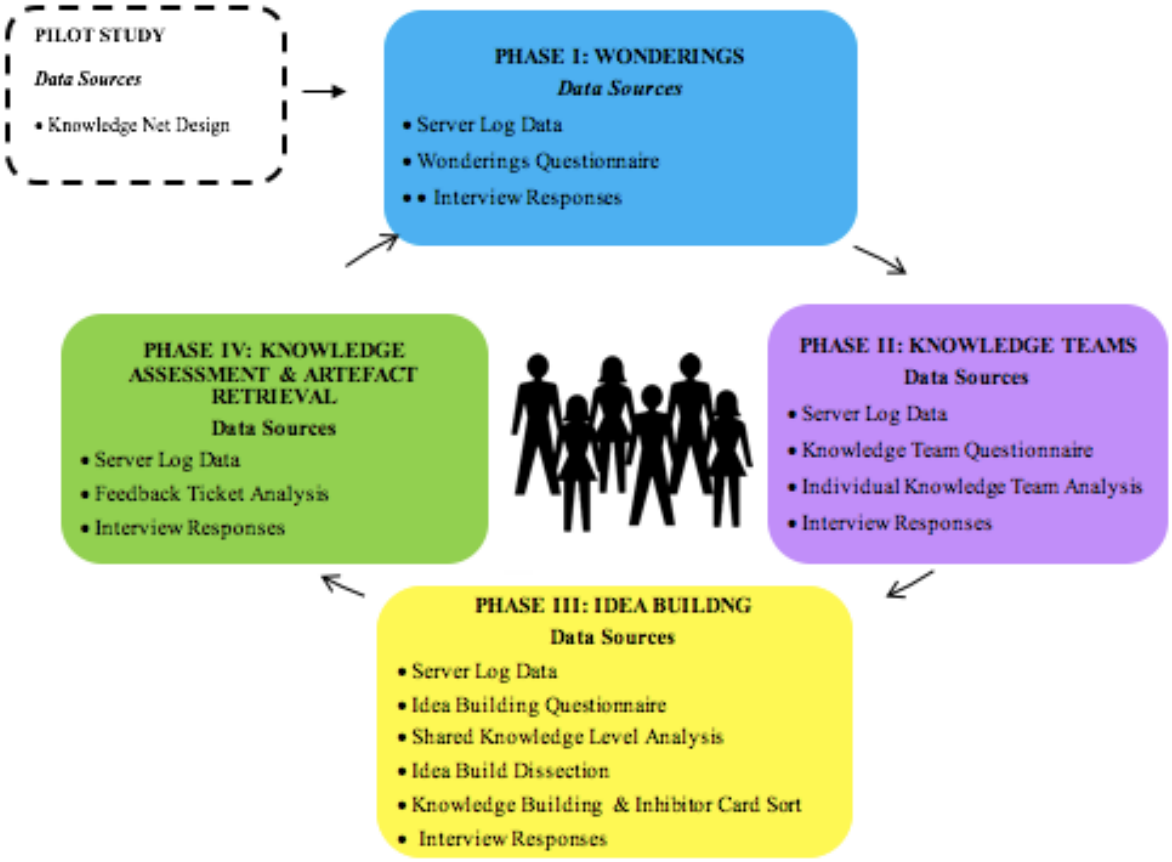

Figure 7. Alignment of data sources with the conceptual framework.

Another important component of this case study design was a case study protocol that contained a description of the instruments, procedures and general guidelines that were implemented during data collection. In addition to increasing the reliability of the case study, the use of a case study protocol ensured that a clear process was followed during data collection and

analysis of the research design. The next section of this chapter provides a detailed description of the data collection procedures that were implemented during this study

Server log data. Knowledge is a socially-mediated product that is rooted in individual interaction patterns about ideas and issues. Scott (2011) suggested that an individual's position within a social context plays an important part in determining what specific information an individual is exposed to and has access to within a network community. Therefore, if individuals in different social positions receive different information, they may come to create knowledge in individually unique ways.

Server Log data were extrapolated to provide detailed information regarding individual and group interactions within a networked environment. To measure participant interactions, the following four measures for online knowledge building were used:

1) Number of Wondering posts created: This is included because it is the most commonly used measure that is attributable to online participation.
2) Reading patterns within Wonderings posted: The number of posts read within a network is an important measure for assessing community awareness and knowledge construction. Zhang, Scardamalia, Reeve and Messina (2009) found that one cannot engage in dialogue without knowing and understanding what others have written. Analyzing the reading patterns of various network members provided insight into how knowledge was initially developed and shared in the network.
3) Number of linked Wonderings: This measure tracks the interaction patterns of an individual participant within Knowledge Net. It is directly linked to an individual's ability to collaborate, link, and join with others to develop knowledge.

4) Scaffolded Wonderings: This measure refers to the number of Rise Above notes that participants utilized within Knowledge Net. Scaffolds demonstrate the ability of an individual to combine ideas, create better theories, or frame and improve upon earlier ideas making knowledge building more accessible to others within the knowledge building community. Using the scaffolding features within Knowledge Net allows participants to link and expand on ideas creating a network of ideas and supports the development of idea diversity through collaborative inquiry.

Data arising from the discourse and interactions among teachers within the Wonderings Discussion Forum provided a cumulative collection of individual social dynamics and interactions. All online posts were analyzed using a multi-method approach that combined both social network analytics and content analysis of individual messages. The use of various analytics allowed a broader perspective of both the structural features of the message threads as well as the knowledge building principles to emerge within the discussion forum.

Data derived from questionnaire responses were also collected to examine how teachers experienced the knowledge creation process throughout all four phases of the conceptual model. Knowledge building principles were tested within the questionnaire items and feedback was collected to inform the design and modifications of the digital tool.

Questionnaires. To better articulate the development of community-shared knowledge building, questionnaires were created based on the 12 knowledge building principles developed by Scardamalia (2002). This research focused on the role and impact of nine of these knowledge building principles outlined in Table 1.

Table 1

Definitions of Knowledge Building Principles

No.	Knowledge Building Principles	Definition of Principle
1	Real Ideas and Authentic Problems	Knowledge problems arise from our efforts to understand the world around us. Problems that provide the greatest promise of knowledge building are those that Knowledge Builders care about because they are relevant to their lives.
2	Improvable Ideas	Effective knowledge building requires a safe arena where knowledge building members can share, build, and co-create ideas together, while constantly reflecting and improving on those ideas.
3	Idea Diversity	Idea diversity is essential to effective knowledge advancement. To develop knowledge, we must understand all facets of an idea and all the ideas that surround it. Idea diversity creates a rich environment for the evolution of ideas and the refinement of those ideas.
4	Rise Above and Scaffolding of Ideas	Creative knowledge building construction requires building and working towards higher-level understandings of problems and ideas. Effective knowledge building requires synthesis and the ability to move to higher levels of knowledge construction.
5	Epistemic Agency	Effective Knowledge Building requires that all knowledge building members set forth their own ideas, negotiate personal ideas with the ideas of others, and use contrast to spark discussion that seeks to advance knowledge within the knowledge building community.
6.	Knowledge Community and Collective Responsibility	Shared knowledge building requires that co-constructed knowledge be shared with other members within the knowledge building community. These newly created Knowledge Artefacts represent the collective shared knowledge of a group of Knowledge Builders and provide opportunities for the overall advancement of knowledge in the community.

7	Knowledge Building Discourse	The discourse of a knowledge building community results in more than the sharing of knowledge; the knowledge itself is refined and transformed through the discursive practices of the community, where the advancement of knowledge is the community's explicit goal.
8	Constructive Uses of Authoritative Sources	To build on knowledge, it is important to understand the present and growing edges of research and evidence related to the ideas and the knowledge that is being constructed. Members need to have a strong understanding of authoritative sources as well as the ability to take a critical stance of the viewpoints that exist with regards to the ideas being developed and improved in a knowledge building community.
9	Embedded and Transformative Assessment	Assessment can help advance knowledge within a knowledge building community and is used to identify problems with new knowledge constructions as well as fine-tune knowledge as it continues to be shared and developed.

Note: The knowledge building principles were adapted from Scardamalia (2002).

The goal of the questionnaires was to neither measure nor classify the principles within the conceptual model, but rather to better understand how the knowledge building principles developed and supported teacher interactions during the knowledge creation process. Six questionnaires were developed to analyze the iterative processes of knowledge building throughout the four stages presented within the conceptual model. Participants were invited to respond to the questionnaires through email and the online messaging system within the network tool. Follow-up reminders were sent to non-respondents after one week using the tool's online messaging system to ensure that all questionnaires were completed. Participant responses were anonymized within the network tool and the data were extrapolated and compiled in Microsoft

Excel spreadsheets for further analysis. Below is an outline of the structure and focus of each of the questionnaires administered in this study.

Pre-assessment. At the beginning of the study all participants were invited to a full-day professional development workshop that introduced the conceptual model of shared professional knowledge creation and outlined the nine knowledge building principles that form the foundational framework for the development of the network. Participants also received training on the digital tool and its various knowledge building features.

When participants first entered the network, they were guided through an online pre-assessment questionnaire. The focus of the pre-assessment was to examine teachers' views on collaboration, preferences for professional learning, and their current understanding of knowledge building and shared knowledge creation (See Appendix A). The nine questions within the pre-assessment were aligned with the nine knowledge building principles, and a four-point Likert scale ranging from *Strongly Agree* to *Strongly Disagree* was used for each question. Teachers were also presented with five levels of teacher expertise, outlined in Table 2, and were asked to self-select the label that best described their perception of their level of teacher expertise.

Knowledge Net design questionnaire. A questionnaire was also developed to assess the digital tool's perceived ease of use and its ability to support shared knowledge creation (see Appendix B). The questionnaire was divided into nine parts that aligned with the nine key knowledge building principles and participants were asked to indicate on a four-point Likert scale the extent to which they agreed or disagreed with a list of statements concerning the digital network's knowledge building tools.

Table 2

Levels of Expertise for Teacher (Self-Identification)

Level of Teacher Expertise	Description of Knowledge, Skills and Dispositions
Novice	Developing basic skills; recently new to the teaching profession; loosely developed knowledge based on personal experience and initial coursework; limited professional experience. (0–1 year teaching experience)
Apprentice	Some initial practical knowledge; emerging understanding of pedagogy and practice; still relatively new to the teaching profession. (2–3 years of teaching experience)
Specialist	Most classroom and content development has been completed; basic mastery of teacher pedagogy; usually adheres to routines or formalized methods of teaching. (4–6 years of teaching experience)
Master	Specialized knowledge in teacher subject area is present; ability to adapt and improve teaching resources is present; competent pedagogical practices are demonstrated in the classroom. (several years of teaching experience)
Expert	Crystallized expertise in subject area; fluid pedagogical practice is demonstrated in the classroom; current research practices are evident in instructional and assessment practices; improved student learning is evident in classroom data. (several years of teaching experience)

This questionnaire was first administered at the end of the pilot study to help with the development and modification of the network tool and its various knowledge building features. To further test the development of the digital tool, the same questionnaire was administered a second time at the end of the study to all participants to test if the modifications had effectively supported shared knowledge creation and to determine if any further enhancements may be required.

My Wonderings participant questionnaire. The first phase of the conceptual model focused on knowledge building discourse and collaborative inquiry. To better understand the depth of inquiry and social structures needed to support teachers as they initiate knowledge building within the Wonderings Discussion Forum an online questionnaire was developed that was administered to all participants at the end of the third month of the study. The questionnaire contained nine items that focused on teachers' exploration of real ideas and authentic problems (see Appendix C). The knowledge building principles of idea diversity, improvable ideas, and epistemic agency were aligned with the questionnaire items to provide further data on the initial interactions and identify connections teachers developed within phase one of the conceptual model.

Knowledge Team participant questionnaire. In the second phase of the conceptual model, the development of Knowledge Teams was used to create shared Idea Builds. A questionnaire containing 11 items was constructed to measure the collaboration and interaction within the Knowledge Teams. The first nine items aligned with the nine knowledge building principles and asked participants to use a four-point Likert scale to indicate their level of agreement with each question. The final two items asked participants to use a four-point Likert scale (ranging from very high to very low) to rate the level of knowledge building and

collaborative interactions of their Knowledge Teams (see Appendix D). The *Knowledge Team Participant Questionnaire* was then administered at the end of the fifth month and was made available to all participants in the study, including those participants who had not joined a *Knowledge Team*. Data from the questionnaire was collected and transposed onto a Microsoft Excel spreadsheet.

Idea building participant questionnaire. The third phase of the conceptual framework focused on shared Idea Building and was the main phase of the knowledge creation process. To further examine the collaborative efforts of teachers as they developed shared Idea Builds and Knowledge Artefacts in the network, an *Idea Building Participant Questionnaire* was constructed with 17 items that focused on four key knowledge building principles: 1) Real Ideas and Authentic Problems, 2) Improvable Ideas, 3) Constructive use of Authoritative Sources, and 4) Collective Responsibility (see Appendix E). Participants were asked to indicate their level of agreement for each of the 17 items using the same four-point Likert scale developed in previous questionnaires. The questionnaire was administered to all participants in the study using the online survey tool within the network and responses were compiled in a Microsoft Excel spreadsheet.

Post-assessment. The final questionnaire for the study was a replication of the initial pre-assessment and contained the same nine questionnaire items. Participants were asked to indicate their level of agreement using the same four-point Likert scale (see Appendix F). The post-assessment focused on the professional learning opportunities provided to the teacher participants and explored the changes and challenges of professional learning that developed over the course of the study. The post-assessment also provided an opportunity for participants to reflect on their experiences within knowledge building network.

The use of questionnaire data provided multiple data points that measured participant experiences and individual understandings of shared knowledge creation. The next set of data collected during the study was a series of knowledge objects created by teacher participants in the network.

Collection of knowledge objects. The collection and analysis of knowledge objects helped corroborate the theoretical propositions aligned with the four phases of knowledge creation in the conceptual framework. The purposeful selection of four Knowledge Builders, a Knowledge Team, and an Idea Build were the main knowledge objects used for further data analysis. Assessment Artefact Tickets were also collected and analyzed to measure the level of transformative assessment that occurred within the network and its impact on effective knowledge creation. The following section provides a detailed description of the criteria that were used to select the knowledge objects and the method used to collect the Assessment Artefacts Tickets.

Knowledge Builder profiles. The focus of this case study was to understand how knowledge is created and shared among various teachers by examining specific knowledge building behaviours and interactions. By selecting four Knowledge Builders from the network, I could examine what motivated certain teachers to share ideas and thus initiate the process of knowledge building. I used the following criteria to select the four Knowledge Builders for further analysis:

1) The four selected Knowledge Builders demonstrated a variety of teacher expertise and professional contexts.
2) Each Knowledge Builder demonstrated a different level of engagement within the network.

3) The Knowledge Builders presented unique knowledge building behaviours that contributed to overall understanding of knowledge building in the network.

The creation of four individual Knowledge Builder Profiles from the above selected criteria provided a broad perspective of the types of knowledge-sharing activities that occurred in the network and allowed a deeper analysis of the social interactions involved in shared knowledge creation.

Knowledge Team selection. Knowledge that is embedded within a community transcends individual contributions and requires a closer analysis of the knowledge building processes utilized by groups of teachers rather than the end products that have been developed. One Knowledge Team in the network was purposefully selected to explore and analyze the interactive and social context of knowledge building. The following criteria were used to select the Knowledge Team:

1) The Knowledge Team included multiple Knowledge Builders from a variety of professional contexts.
2) The Knowledge Team Wonderings Forum was utilized to support ongoing team discussions.
3) The Knowledge Team created Knowledge Artefacts that were shared with the network community.

Knowledge building is a social process and therefore an essential component of analyzing a community of Knowledge Builders is collecting data that demonstrate the interactions and collaborative knowledge building structures that individual teachers used to share their professional expertise. The selection of one Knowledge Team for analysis provided an opportunity to closely examine how teachers negotiate and develop shared knowledge by

combining individual expertise and specialized skills using various interactions and collaborative knowledge building strategies.

Idea Build selection. Idea development is a foundational building block of shared knowledge creation. Scardamalia and Bereiter (2003) identified that the development and scaffolding of ideas within a collaborative community is an essential component of the knowledge building process. For this case study, ideas were viewed as conceptual artefacts that developed through discourse, interactions, and collective inquiry. The Idea Builds created in the network were collected and examined as evidence of the processes and interactions involved in the knowledge creation process. Knowledge labels were attributed to all Idea Builds and, after the Idea Builds were coded, one Idea Build was purposefully selected for further analysis using the following set of criteria:

1) The Idea Build demonstrates multiple interactions from a variety of Knowledge Builders.
2) The Idea Build includes examples of a variety of knowledge building principles.
3) The Idea Build provides an example of complex knowledge building discourse patterns and higher levels of knowledge construction.
4) The Idea Build illustrates ongoing collaborative inquiry and knowledge advancement.

The coding and analysis of the selected Idea Build is discussed in the Data Analysis section of this chapter.

Artefact Assessment Tickets. Embedded assessment within the network is necessary to support the continuous advancement of ideas and knowledge creation. Providing opportunities for the network community to engage in internal assessments of shared Knowledge Artefacts not only develops collective responsibility, but also encourages individual teachers to work at the

cutting edge of their professional practice. During the pilot study, participants indicated that a feedback system was needed to better support the assessment of shared artefacts. Accordingly, an Artefact Assessment Ticket was created in the digital tool to support the continuous improvement of shared network artefacts by allowing teachers to provide feedback to other network members and develop and revise various knowledge artefacts. At the end of the case study, all Artefact Assessment Tickets were collected and analyzed to determine how embedded transformative assessment is best supported within a networked environment. A detailed description of the coding and analysis of the Artefact Assessment Tickets is discussed in the Data Analysis section of this chapter.

Finally, semi-structured interviews were conducted at the end of the case study. The following section provides a detailed outline of how the interviews were conducted, how data were collected, and the implementation of two card sorts (defined below) that were part of the interview process.

Semi-structured interviews. Semi- structured interviews were conducted in both the pilot study and the final phase of the study to collect additional data on the use and effectiveness of a shared knowledge building network. An interview script was developed with eight open-ended questions (see Appendix G). During the pilot study the interview questions were tested for the purpose of "…clarifying the intention of questions, justifying the inclusion of certain questions, trying to eliminate ambiguity…and designing questions that will be easy for participants to understand" (Brunton & Coll, 2005, p. 149).

Accordingly, two participant interviews were conducted at the end of the pilot study to collect data on individual knowledge building experiences within the digital tool as well as to

gather feedback on the interview questions. The feedback from the pilot study and the adjustments made to the interview script are detailed in Chapter 4.

Final interviews with ten selected participants occurred at the end of the data collection phase of the study. These participants were purposively selected to represent a variety of teaching professional contexts, levels of teacher expertise, and engagement within the knowledge building network. The goal of participant selection for these interviews was not to select teachers that exhibited common characteristics of network members, but rather to select participants that demonstrated exceptionalities or unique knowledge building experiences that could maximize my depth of understanding of shared knowledge creation and help me develop a broader perspective of teacher knowledge creation. At the end of each participant interview, I implemented the following two card sorts.

Card sorts. Card sorting is used by software designers to better understand categorization and relationships between items. Fincher and Tenenberg (2005) introduced the concept of card sorts as a method for providing participants opportunities to share their insight into how items are categorized within various processes and how information is organized and clustered. Card sorting can either be open, where participants are asked to sort a set of cards into as many groups and categories as desired, or closed where a pre-determined organizational structure has been provided. During individual interviews, I administered two closed card sorts to the ten selected interview participants to investigate the individual experiences of knowledge building in the network and identify barriers to successful shared knowledge creation. A script was developed to ensure that a consistent method was followed for both card sorts and that the process was similar for each interviewee (see Appendix H).

Knowledge building principle card sort. The first card sort focused on participant perceptions of shared knowledge creation in the network with relation to the nine Knowledge Building Principles. Interview participants were provided with a set of nine index cards, each with the title and definitions of the nine knowledge building principles outlined in this study (see Appendix I). Participants were also provided with several blank cards and a marker. The cards were shuffled and provided to interviewees as a completed stack. Individual interviewees were then instructed to:

1) Organize the cards in a chronological order that best reflected their personal experience of shared knowledge building in a networked environment.
2) Talk through the card sorting process, stating rationales for placement of cards.
3) Set aside any cards they felt were not a part of their knowledge building process.
4) Use the blank cards provided to create new cards for anything the they felt was missing from the process.

During the card sort, notes were taken to capture participant rationales and comments. When the sort was complete, I recorded the order of the cards and noted any blank cards that were created, then conducted a second card sort described below.

Knowledge building inhibitors card sort. The second closed card sort focused on the nine Knowledge Building Inhibitors identified in the pilot study. For this card sort, the nine Knowledge Building principles that were initially sorted by the participant remained in front of the interviewee. For this second sort, interviewees were presented with a second set of index cards, each with the title and definition of one of the nine Knowledge Building Inhibitors printed on them (see Appendix J). Interviewees were again provided with several blank cards and a

marker. The cards were shuffled and presented as a stack for the participants to organize. The interviewees were asked to:

1) Rank the Knowledge Building Inhibitors in relation to greatest impact on shared knowledge creation.
2) Talk through their card sort and provide any rationales or comments as they organized the nine cards.
3) Set aside any cards they felt did not inhibit their knowledge building experience.
4) Use the blank cards provided to create new cards for any Knowledge Building Inhibitors the interviewees felt were missing from the sort.
5) Align the Knowledge Building Inhibitors with the Knowledge Building Principles according to the area of impact.

Notes were taken during the card sort, and I documented any rationales or comments made by the interviewees. When the initial sort of the Knowledge Building Inhibitors was completed, I recorded the order of the cards. When the final alignment of Knowledge Building Inhibitors with Knowledge Building Principles was completed, I copied the final placement of all the cards. In my notes, I also recorded any additional cards that had been created, or cards that were set aside. The results of both card sorts were recorded on a Microsoft Excel spreadsheet for further analysis.

Methods of Data Analysis

The analysis of data for this case study followed a theory-building structure that aligned with the four phases of knowledge creation outlined within the conceptual framework. To better manage and organize the large amounts of data collected, a systematic case study codebook was developed that guided the analysis of online posts and knowledge artefacts created in the

network (See Appendix K). The coding of data throughout the case study allowed me to see the patterns and themes that emerged through the iterative cycles of knowledge creation and provided me with a broader understanding of the social context and discursive structures required to support successful knowledge building.

In order to ensure confidence with regards to the findings of this case study, the data analysis consisted of two concurrent flows of activity: data reduction and data displays. These activities were not done in isolation of analysis, but rather were a part of the analysis and helped to focus and organize the data in such a way that themes, patterns and final conclusions could be drawn and verified.

Data reduction. Several data reduction methods were used throughout the data analysis process. Initially, anticipatory data reduction methods were used to help bound and focus the data that was collected. First, the conceptual framework developed for this case study acted as a guide for determining the main data sets that needed to be collected to align with the four phases of knowledge creation outlined in the framework. I also used my research questions as another bounding device for the data that I collected. The research questions for the case study helped determine the specific areas of the phenomena that I wanted to investigate and explore. I also used contact summary sheets (Steele, 2010) to summarize the information, main themes, key ideas that participants shared that were aligned with the conceptual framework and my research questions. Finally, I created a coding scheme (See Appendix K) that aligned with my conceptual framework and research questions. Using both descriptive codes and explanatory codes I was able to interpret the interactions, words and phrases in my data using a set of clear criteria and conventions. Using the above anticipatory data reduction methods served as a starting point for my data analysis and helped organize and focus the data and guided my analysis of the data. The

coding scheme that I developed occurred continuously throughout the research study. I cycled back and forth between the four phases using the existing data sets to lead to further data analysis that lead to deeper and richer understandings of the patterns and themes that emerged through the data analysis process.

Data displays. Due to the iterative nature of knowledge building a system had to be developed to explore the data through the various phases of shared knowledge creation. I chose to use data displays to help me visualize the relationships and patterns that were emerging from my various data sets. Using a series of descriptive matrices (Miles & Huberman, 1984) I was able to display several variables at once and identify key connections and areas of challenge. I used a descriptive matrix to track the emergence of the seven knowledge building principles throughout the case study. Individual participant data was coded and displayed in an Microsoft Excel spreadsheet to illustrate the development of the various knowledge building principles. As patterns and themes emerged within the data displays I re-coded the data again and began to conceptually-cluster the data based on the coding scheme I had used earlier during the data reduction phase. Each individual data display was then synthesized onto a larger meta-matrix that illustrated all the participant data. This larger meta-matrix allowed me the opportunity to see individual participant activity throughout the case study. Each cell in the spreadsheet was colour coded to align with the codes from the case study code book. This color-coding schemed allowed me to easily traced individual participant activity back to the original coding from the interview transcripts or questionnaire data. The use of data displays allowed me to sort and re-organize the data using the different knowledge building processes that were identified and clearly see new emerging patterns and themes.

The following section provides a detailed outline of the data analysis procedures implemented in this case study.

Social network analysis. Hanneman and Riddle (2005) used social network analysis (SNA) to investigate how actors are embedded within a network by analyzing various relationship and interaction patterns. SNA provides a deeper analysis of the relationships that exist between people and their interactions in the network. The two main building blocks that form the basis of network analysis are: 1) nodes that represent the agents within a social network and 2) ties or edges that illustrate the various relationships and interactions that occur between network members.

Using specialized software and mathematical equations, the intricate connections and interactions that occur in networks are demonstrated pictorially using sociograms. The sociograms reconstruct the various social processes within a network and illustrate the complex interactions involved during the dissemination and creation of shared knowledge between various individual network members. The following four SNA measures were used to examine the interactions and knowledge building behaviours in the network created for this study.

Degree centrality. Centrality is a structural characteristic of an individual and his or her placement within a network. Degree centrality is the measure of the number of ties an individual has within a network. This is an important measure because it demonstrates the communication activity of an individual during various network activities. Closeness centrality measures how connected one individual is to another in a network and indicates the level of independence or interdependence among various network members. All three centrality measures are important data sources for a knowledge building community because they measure the shape of knowledge transfer within and between individuals and groups.

Density. The density of a network indicates how many pairs of individuals have interacted compared to the total number of pairs of individuals within the entire network. Density is an important measure within a network because it reflects the number of interactions or pathways that have occurred between network members rather than simply indicating the volume of communications.

Equivalence. Equivalence of two individuals within a network indicates that they are embedded in equal or similar network structures and share similar roles. Reagens and McEvily (2003) suggest that knowledge flows more easily between those individuals that share equivalent roles and that analyzing network equivalence reflects how knowledge is shared and retained by individuals according to their position within a network.

Betweenness. Participants assume a variety of roles and positions within a network. Analyzing the number of times an individual stands between another individual within a network with regards to communication or a network tie provides information about an individual's control of the communication within the network. A high degree of betweenness within a network indicates that certain participants hold power with regards to knowledge transfer and construction.

Brokerage. A broker is defined as an agent who holds a position that connects two or more parts together within the network. Brokerage is closely related to the bridging of ideas within a social network; studies suggest that brokerage may be fundamental for the creation of innovative ideas (Burt, 2005; Dekker, Fleischmann, Inderfurth, & Van Wassenhove, 2004). An analysis of brokerage within this study's network provided data about key participants, and their ability to act as brokers for idea sharing and knowledge exploration.

For this case study, I used the social network analysis software, *Social Network Visualizer*, to analyze server log data. The following section is a brief description of the social network analytics that were implemented in this case study.

Following the conceptual framework and data collection process, I extrapolated all Wonderings posted within the network and analyzed the data for measures of centrality, density, betweenness and brokerage. I created radial sociograms to profile different kinds of Knowledge Builders and their various interactions and relationships within the network. During the second phase of the case study, I created a series of sociograms of the pre-selected Knowledge Team and tracked the interactions and knowledge contributions of the various group members. For the third phase of the conceptual model that focused on idea development, I analyzed the ideas created and posted by all participants within the network and presented a sequence of sociograms that tracked the development of the purposefully selected Idea Build. In the last phase of the knowledge creation process, the network analytic that I used to examine the Wonderings posts and the various Knowledge Artefacts in the network was a sociogram that provided data and evidence of the structural processes needed to support knowledge building in the network.

Codes and coding. To code online posts and Knowledge Artefacts in the case study, I used a methodological approach that supported both analytic and iterative cycles of content analysis. The continuous analysis of content developed in the network allowed a close examination of the divergent perspectives and multiple interactions and discursive structures teachers utilized throughout the four stages of shared knowledge building. The coding of all the data sources focused on analyzing the level of knowledge associated with various network objects and individual knowledge building behaviours.

Coding of online Wonderings. One of the strengths of online discourse is that participants leave a textual path of both their interactions and discussions that can be traced and analyzed. An initial analysis of the server log data provided an opportunity to examine how many posts a participant had created, the percentage of posts that were linked to other posts, and how many Rise Above scaffolds a certain participant used within the network.

Individual posts were analyzed using *The Interaction Analysis Model for Examining Social Construction of Knowledge in Computer Conferencing* developed by Gunawardena, Lowe, and Anderson (1997). The underlying principle of this analysis tool is the belief that knowledge construction evolves through a series of phases. These various phases formed the basis of the codes that were attributed to individual online-posted Wonderings.

Determining the level of shared knowledge constructed within the network. Idea Builds in the network were examined and analyzed for evidence of shared knowledge building processes and collaborative social structures. After exploring the interactions and discourse patterns within each Idea Build, I attributed specific knowledge labels to all the Idea Builds within the network that were adapted from the *Levels of Working with Knowledge* created by Bereiter and Scardamalia (1998). These knowledge labels outlined in Table 3 were used to indicate increased levels of collective responsibility and shared idea exploration.

Table 3

Knowledge Levels for Idea Builds

Knowledge Level	Label	Description
Representative Knowledge Artefacts	1	Artefacts come from external authoritative sources such as a published teacher resource or pedagogical programs.
Personally-Constructed Ideas	2	Individual knowledge and expertise is developed into an Idea Build.
Semi-Autonomous Idea Build	3	Knowledge and expertise is combined between two individuals to develop a shared Idea Build.
Collective Knowledge Artefacts	4	Knowledge Teams share their knowledge and expertise to create a co-constructed Knowledge Artefact.
Transformative Knowledge Artefacts	5	Pervasive idea exploration and collaborative knowledge advancement develop innovative Knowledge Artefacts.

I used descriptive coding to identify Idea Builds that aligned with the various characteristics at each knowledge level. I then grouped the Idea Builds by level and used this information and server log data to develop the sociograms for the Idea Build dissection.

Analyzing the impact of internal community knowledge assessment. As collaborative groups of teachers discover and share ideas to co-construct knowledge artefacts, they also need opportunities to evaluate and provide internal assessments that lead to higher levels of knowledge creation and innovation. According to Scardamalia (2002) embedded and transformative assessment is integral to knowledge building because it helps to advance the collective wisdom of a community through identifying problems and gaps as ideas are processed and developed. Zhang, Hong, Scardamalia, Teo, and Morley (2011) found that the ability to

sustain idea sharing and knowledge building requires groups of individuals reflecting on knowledge assets and "engaging in idea centered discourse involving multiple perspectives, constructive criticism, and distributed expertise" (p. 266).

The final phase of the conceptual framework required teachers to assess the Knowledge Artefacts that were shared in the network. Teachers used an Artefact Assessment Ticket to provide feedback on shared knowledge assets in the network. The purpose of these tickets was to improve and advance collective knowledge. To better understand how transformative assessment impacted knowledge building, I analyzed and coded all Artefact Assessment Tickets using the Knowledge Artefact Assessment Principles outlined in Table 4.

Table 4

Knowledge Artefact Ticket Assessment Principles

Knowledge Artefact Assessment Principles	Weight	Description
Working at the Cutting Edges of Teacher Professional Practice	1	Identifying knowledge gaps while extending the edges of professional knowledge
Constructive Use of Authoritative Sources	2	Use of information from a variety of external resources and teacher expertise to support and scaffold ideas.
Progressive Problem Solving	3	Demonstrate continual idea development and exploration by scaffolding and building on the understandings and ideas of other network members.
Collaborative Knowledge Inquiry	4	Provide new insights and continually question current professional problems to further develop the application of knowledge artefacts and spark deeper community discussions.

The coding of the assessment tickets was compiled in an Microsoft Excel spreadsheet and emerging themes and patterns were highlighted. Specific Artefact Tickets that demonstrated the highest principle of Collaborative Inquiry were flagged and a data display table was created that tracked the development of the initial Idea Build and its various iterations of feedback and improvement. An analysis of the methods teachers used to assess shared knowledge artefacts illustrated how embedded transformative assessment translated into specific processes and interactions in the network.

Analyzing questionnaire data. Six questionnaires were administered during this case study and a Microsoft Excel spreadsheet was created to store all the questionnaire data. For each questionnaire, individual responses were first recorded according to the level of agreement using a four-point Likert scale (Strongly Agree to Strongly Disagree). Descriptive statistics were used to determine frequency counts and mean. Questionnaire items were then aligned with the nine knowledge building principles to identify areas of challenge that developed during the knowledge creation process. Data from the questionnaires were then used to create a series of graphs and tables to further illustrate how teachers engaged in knowledge building discourse and collaborative inquiry.

Individual analysis of network objects. Examining network objects provided further information that captured the specific interactions and collective structures required for successful knowledge creation. Network analysis of both Knowledge Teams and Idea Builds provided a multidimensional analysis of the relationships formed within the network and of the sequential organization and development of shared knowledge artefacts.

Knowledge Team analysis. Knowledge Teams that formed within Knowledge Net constituted the smallest group of participants who directly interacted with one another while co-

constructing knowledge. Using Social Network Analytics, the pre-selected Knowledge Team was examined for centrality, density, betweenness and brokerage. The composition of the Knowledge Team was then further explored by investigating the individual interactions of the various nodes (teachers) and different kinds of edges (interactions). The level of reciprocity and knowledge contributions for the team was also examined. Sociograms were then created to present a visual representation of the behaviours and structures needed to support effective collaborative ideas development.

Idea Build dissection. If cognitive objects such as Idea Builds are developed among and between various Knowledge Builders, then the dissection of a specific Idea Build can provide further insight into the knowledge building discourse and exchange patterns involved in shared knowledge creation. The focus of the Idea Build dissection was to examine the social processes and pervasive Idea Building structures that teams of teachers utilized as they shared and engaged in group idea development. Using Social Network Analytics, server log data related to the Idea Build was analyzed for centrality, density, betweenness and brokerage. The data were then used to create a series of sociograms that illustrate the sequential steps involved in knowledge building. These sociograms also provided details about the structural components within the network that were utilized by teachers during shared idea development.

Interview data analysis. An iterative analysis of the interview data was implemented where data were initially reviewed to identify key ideas and essential understandings. First, notes were taken for each interview and a contact summary sheet (Steele, 2010) was developed to assist with the identification of key themes, patterns, and essential questions that emerged during the interviews. The contact summary sheet (See Appendix L) contained a list of the nine knowledge building principles and knowledge inhibitors identified for this study. These were

checked if they were mentioned during the interview. The summary sheet also contained the research questions for this case study and included the conceptual framework for quick reference. Individual contact summary sheets were completed immediately after each interview, and provided an opportunity for me to reflect on the interview data and include any significant notes or reflections that I felt were important to the development of the case study.

After I explored and compiled the data from the contact summary sheets, I coded the transcripts for emerging key themes and patterns. Using a colour-coding legend, I identified passages and comments that aligned with the knowledge building principles and Knowledge Building Inhibitors. I re-examined all the interview data and, using the *Interaction Analysis Model for Examining Social Construction of Knowledge in Computer Conferencing* (Gunawardena et al. 1997), I coded any interactions that were mentioned during the interviews. When I had coded all data and no new themes or patterns emerged from the data set I felt saturation was reached. I then constructed data summary tables of the key themes and patterns in a Microsoft Excel spreadsheet.

Analyzing the card sort data. Data from the Knowledge Building and Knowledge Inhibitor card sorts were analyzed using a series of data matrices that helped to easily identify relationships between individual items within the card sorts. Exploratory analysis of participant comments and researcher field notes were also organized in a data display table to help identify any key themes and patterns.

To determine agreement between individual card sorts, a rank order matrix was constructed that showed the prioritization of the nine knowledge building principles by individual participants. This matrix provided an opportunity to identify common rankings of specific knowledge building principles and indicated strong relationships among interview

participants. Examining the common relationships of the ten interviewees within the matrices illustrated individual knowledge building experiences in the network and identified which Knowledge Building Inhibitors had the greatest impact on specific knowledge building principles.

Finally, I conducted exploratory analysis of the notes and comments I recorded during the card sorts to provide a clearer understanding of why cards were placed in a specific order, what relationships existed between various knowledge building principle, and inhibitors, and how individual teachers experienced shared knowledge building in the network. The participant data from the card sort was first colour-coded by knowledge building principle. Knowledge building inhibitors were then labeled to identify key relationships or areas of impact. Finally, key themes or patterns that emerged from the card sort data were labeled on the field note sheets and these were compiled and transposed onto a Microsoft Excel spreadsheet.

Throughout the data analysis, my role was to act as a meaning maker, which requires, as Patton (2002) emphasized, the importance of deep synthesis with regards to data analysis. This requires the ability to move beyond the reporting of empirical facts and information found within the research findings, and closely scrutinize and weave important themes and ideas together to clearly answer research questions. To establish confidence with this case study's findings the issues of validity, reliability and trustworthiness will be discussed in the following section to indicate that the integrity of the case study was maintained.

Integrity of the Study

Yin (2014) proposed four critical tests that ensure design quality: 1) construct validity, 2) internal validity, 3) external validity, and 4) reliability. The application of these design quality tests are summarized in the following section.

Construct validity. Construct validity refers to the degree to which the right operational measures have been selected to accurately measure the phenomenon of interest (Yin, 2014). This refers to the extent to which a study's findings lead to an accurate description and observation of reality (Denzin & Lincoln, 1994).

One of the main challenges of case study research is to develop a well-considered set of actions and collection methods rather than relying on subjective judgments with regards to data analysis (Yin, 2014). Two main strategies for ensuring construct validity within case study research are different data collection methods and different data sources (Denzin & Lincoln, 1994; Stake, 1995; & Yin, 2014). By providing multiple measures of the same phenomena, researchers ensure they are addressing construct validity, while also maintaining the focus and integrity of their study. To address concerns regarding construct validity, this case study employed multiple sources of evidence and different data collection methods such as questionnaires, interviews, direct observations, and discourse analysis throughout all four phases of the knowledge creation process to provide multiple perspectives with regards to the phenomena being studied.

Also, a clear chain of evidence was established to "…follow the derivation of any evidence from initial research questions to ultimate case study conclusions" (Yin, 2014, p. 22). This was achieved through the development of a case study protocol that outlined how data were to be collected, the use of an external case study database that stored all case study evidence, and a detailed account of the data analysis methods.

Internal validity. Internal validity refers to the presence of causal relationships between variables and results. Where construct validity is relevant with regards to data collection, internal validity applies more to the data analysis phase (Yin, 2014). To ensure that a study has internal

validity, the researcher must develop a plausible causal argument that defends the research conclusions presented within the study. According to Yin (2014) researchers should formulate a clear research framework that demonstrates that variables in the case study lead to specific outcomes and are not caused by additional external factors.

One way to establish internal validity is to align a case study with theoretical propositions. For this single case study, a clear conceptual framework based on current knowledge creation theories was used to align research findings with existing theory. Pattern matching of the data from this case study was compared with the theoretical propositions included within the conceptual framework to see if the patterns coincided. This provided opportunities within the data analysis section to discuss relationships between the case study and previous research and theory development.

External validity. External validity or generalizability refers to the ability of a study's findings to be replicated in other settings. Case study research allows for analytical generalizations through the use of theoretical propositions. Flyvbjerg (2006) clarified that even though, "…knowledge cannot be formally generalized that does not mean that it cannot enter into the collective process of knowledge accumulation in a given field or in a society" (p. 227). While statistical generalizations link observations within a study to a population, analytical generalizations can help inform theory through pattern matching and strong linkages to previous literature and replicated studies. The findings from my case study provided an opportunity to corroborate current knowledge building theory, but it also allowed me to refine my initial conceptual framework to reveal new themes and patterns that emerged during the case study.

Reliability. Reliability refers to the absence of random error so that later researchers can replicate a study and arrive at the same conclusions (Denzin & Lincoln, 1994). Addressing

reliability issues ensures that there are minimal opportunities for researcher error or bias during the case study.

Seale (1999) suggested that reliability can be achieved using "low inference descriptors" (p. 148) or detailed data presentations that make minimal inferences. In my study, the use of a case study protocol and clear methodological procedures provided a clear path that external researchers can use to replicate this study. To ensure that I was addressing issues of reliability within my case study, I provided a careful and detailed description of my data collection and analysis methods. I also developed a case study protocol and a code book that outlined the steps taken during various data analysis procedures. Also, to further ensure reliability, a case study database was set up to organize and store server log data, questionnaire responses, field notes, and other related case study documents.

Trustworthiness. According to Lincoln and Guba (1986), trustworthiness of a research project can be achieved through the triangulation of data sources**.** In the context of this case study, triangulation of the data was achieved through a comparison of the information collected from each of the following data sources: online posts, questionnaires, and individual interviews with participants, as well as by aligning data with respected theories gleaned from the research literature.

By collecting data from multiple sources, I also sought to obtain consistency in observations and findings. The data from the case study were continuously measured against the theoretical propositions outlined within the conceptual framework to corroborate findings rather than relying on individual subjective interpretations of research findings.

Limitations and Delimitations

Limitations of this study fall into two broad categories: 1) knowledge building, and 2) social network analysis. Despite all efforts to effectively analyze various forms of knowledge building activity, it is still difficult to accurately collect data regarding human interactions and individual processes. Knowledge building is an intricate and complex process that is influenced by a variety of factors. Further, our current understanding about the knowledge building process and interactions that occur between knowledge building members is imprecise. At this point, research is only able to define effective knowledge building principles; it is not yet possible to directly link these principles to the measures that have been used within this study to describe knowledge building processes with absolute certainty. Although the data collected in my case study sought to further understand the knowledge building behaviours and complex interactions that support shared knowledge creation, I am not able to report findings related to knowledge building in quantitative terms that would be considered valid, reliable, and generalizable. Instead, I trust the findings from my case study will inform and extend current theories of knowledge creation.

The second limitation of this study is related to the use of social network analysis. Social network analytics demonstrate what interaction pathways exist within a network, but are neutral with regards to content value. For example, social network analytics can show how many posts were read, who read various posts, and how individuals linked and scaffolded posts to other items within a network, but it cannot tell us what knowledge was obtained from the post or how the post changed or impacted an individual's knowledge acquisition. The limited information derived from analytics reduces the ability of social network analysis to determine the

development of knowledge content, thus making it difficult to draw definitive conclusions about the way interactions impact shared knowledge building within a network.

There were three key delimitations of this study. First, was the decision to use a single case study focused on one rural school division. Second, this case study is bounded in a digital network environment that was developed specifically for this research. Third, I purposefully limited the number of participants in the case study to 50 and chose to only interview ten of these participants. Narrowing the research sample allowed me to effectively address the research problem and questions in a manner that was manageable, while still generating rich and detailed research findings.

Ethical Considerations

This case study received approval from the University of Calgary Conjoint Faculties Research Ethics Board (2013). In addition, school jurisdiction approval was sought, and requirements were met to conduct this research.

Several other considerations were addressed with regards to ethics. First, this case study was considered of minimal risk. However, it is important to note that I do work with the participants in this study, and I recognized that my role at a divisional level, while not evaluative, could be seen as a position of power. I realized that some teacher participants might have felt pressured by the evaluative nature of the case study because it focused on an individual teacher's ability to share and build knowledge with other professional colleagues. To address this concern, the informed consent document clearly indicated that appropriate steps were taken to ensure anonymity of all participants. Anonymity of participants was guaranteed using pseudonyms and all participant identifiers were removed from server log data so that no comment or post could be attributed to any one individual. The programmers and network providers also signed

confidentiality agreements and a Secure Sockets Layer (SSL) certificate was obtained to ensure that the data on the network was encrypted and the connections between the web server to the browser were secured. Finally, all case study data were securely stored on an external password-protected hard drive.

Researcher Perspective and Assumptions

I came to this research with my own biases. I believe in the power of professional learning through a networked environment and I created Knowledge Net with the belief that the development of knowledge is best supported through multiple interactions within an asynchronous environment. As a researcher, I had to be aware of my bias. As I worked through the study, I implemented strategies to ensure that my bias was impacting the interpretation of the research findings as little as possible.

I made two key assumptions as a researcher when I began this study. The first assumption that guided the case study was that knowledge building is a mediated process that occurs within the relationships, social processes, and shared experiences of a learning community. A second assumption was the recognition that all ideas are improvable, and that knowledge building is a collective endeavour shared among a community rather than an individual pursuit.

Chapter Summary

This chapter provided an overview and rationale for case study as a research methodology. The research questions and unit of analysis were presented and the data sources and collection methods within the study were outlined in relation to the conceptual framework that was developed for this research. A detailed data analysis plan was also provided, followed by a discussion of the integrity of the study. This chapter concluded with a discussion of measures

taken to address issues of trustworthiness as well as a description of the limitations and delimitations of the study. The following two chapters discuss findings from the pilot study and implementation of the case study. The research findings from the case study are aligned with the four phases of knowledge creation and focus on three main themes: interactions, knowledge building principles, and knowledge building barriers.

CHAPTER FOUR: PILOT STUDY

This chapter presents findings from a pilot study that was developed to assess the effectiveness of the digital networking tool, Knowledge Net, and its ability to support shared knowledge creation among teachers. Three main goals guided development of the digital tool:

1) To make knowledge creation visible and demonstrate how knowledge is created, supported, and shared within a network environment;
2) To build an effective knowledge building infrastructure that is not just a database of resources, but rather a dynamic environment that provides effective knowledge building tools and encourages shared knowledge creation among all network members; and
3) To develop a knowledge building culture and community by encouraging knowledge building discourse and proactive knowledge seeking.

Two kinds of data were collected in this pilot study: 1) questionnaire data from all 20 pilot participants and 2) semi-structured interview data from five randomly selected participants. These data sets were used to determine the perceived ease of use and effectiveness of the knowledge building tool. The identification of major and minor Knowledge Building Inhibitors are discussed in this chapter, along with the implementation of solutions. The following section describes the participants and data collection processes used for this pilot study.

Participants in the Pilot Study

For this pilot study, two professional learning communities totaling 20 participants were selected for a six-month period for the pilot study. At the beginning of the pilot, I provided a 15-minute presentation to all participants to introduce the nine knowledge building principles that were adapted from the *socio-cognitive and technological determinants of knowledge building*

developed by Scardamalia (2002): 1) real ideas and authentic problems, 2) improvable ideas, 3) idea diversity, 4) scaffolding of ideas, 5) epistemic agency, 6) community knowledge building and collective responsibility, 7) knowledge building discourse, 8) constructive uses of authoritative sources, and 9) embedded transformative assessment of knowledge artefacts. I also provided a full-day professional development workshop to introduce the digital tool and its various knowledge building features. During this workshop, participants were shown how to post a Wondering, develop an Idea Build, create a Knowledge Team, as well as store and organize ideas, and share Knowledge Artefacts. A series of video tutorials were also developed to further support the use of the tool and I provided additional ongoing technical support to all participants as needed.

Methods of Data Collection

A questionnaire was developed to assess the participants' perceived ease of use of the digital tool and its effectiveness in supporting the nine key knowledge building principles (see Appendix B). The questionnaire was divided into nine parts, each aligning with one of the nine key knowledge building principles. Participants were asked to indicate on a four-point Likert scale the extent to which they agreed or disagreed with a list of statements concerning the digital network tool's features and effectiveness in supporting shared knowledge creation. The participants were asked to complete the questionnaire at the end of the pilot study, using a survey tool developed within the digital tool.

Semi-structured interviews were also used to collect additional data on the use and effectiveness of the digital tool. The pilot interviews led to minor revisions in the introductory script to ensure that the purpose of the study was clear by introducing the concept of shared knowledge creation. Another question was added regarding the presence of Knowledge Building

Inhibitors to reflect how knowledge building may be impacted within a networked environment. Face-to-face semi-structured interviews were conducted with five randomly selected participants. Each interview lasted 45 minutes and was conducted using an interview script (see Appendix G).

Methods of Data Analysis

Questionnaire data were analyzed with relation to a four-point Likert scale (Strongly Agree, Agree, Disagree, Strongly Disagree) to identify areas of ineffectiveness within the network tool. Frequency counts were used to determine the number of participants that agreed or disagreed with each of the questions. Data from the semi-structured interviews were also coded using an iterative process where the answers and comments of the participants were categorized and aligned with the nine knowledge building principles. The iterative analysis of data led to the identification of nine common Knowledge Building Inhibitors. An alignment between the nine Knowledge Building Principles and the newly identified Knowledge Building Inhibitors can be seen in Table 5. Of the nine inhibitors, five were determined to have a major impact on knowledge creation based on the following set of criteria:

1) More than half of the participants responded negatively to the statement in the questionnaire associated with the Knowledge Building Inhibitor;
2) The Knowledge Building Inhibitor had the greatest impact on a specific Knowledge Building Principle (total number of participants);
3) The Inhibitor impacted more than one Knowledge Building Principle.

These major inhibitors were found to interrupt the flow of knowledge building within the network and, to mitigate these, modifications and enhancements were made to the digital tool.

Table 5

Knowledge Building Inhibitors

No.	Knowledge Building Inhibitor	Definition of Inhibitor	Source
1	Connective Efficacy	The belief that other people who can use the contributed knowledge will receive it and build upon it.	(Kalman et al., 2002)
2	Group Identification	An individual's sense of belonging and identity within a network.	(Chiu et al., 2006)
3	Knowledge Classification & Codification	The time and effort required to codify and input knowledge.	(Kankanhalli et al., 2005)
4	Knowledge Contribution	The perception of increased individual reputation within the network based on knowledge contributions.	(Kankanhalli et al., 2005)
5	Knowledge Self-Efficacy	The belief that an individual's participation and knowledge contributions will make a difference to the success and value of a knowledge building community.	(Kankanhalli et al., 2005)
6.	Offline Interactions	The degree to which network members participate in offline activities related to the network and knowledge development.	(Ardichvili et al., 2003; Ma & Agarwal, 2007)
7	Personal Identity Verification	The perceived confirmation from other members of the network of a member's beliefs, values and contributions within the network.	(Ma & Agarwal, 2007).
8	Professional Evaluation Apprehension	A member's active anxiety that his or her knowledge contributions will be critiqued or evaluated within the network.	(Bordia et al., 2006)
9	System Quality	The extent to which an individual perceives that a particular system is free of effort, easy to use and effectively supports the members within a network and their focused work.	(Davis, 1989)

Identification of major Knowledge Building Inhibitors. The identification of nine Knowledge Building Inhibitors from both the interview and questionnaire data indicated disruptions within the network with regards to knowledge sharing and the organization and management of knowledge content. Each of the inhibitors are discussed in detail in the next section to further demonstrate how knowledge creation was impacted during the pilot study and what modifications were made to the digital tool to better support shared knowledge creation.

Knowledge classification and codification. The first issue that was identified by participants was the absence of a system for knowledge classification and codification. The inability to connect and locate content disrupted the development of real ideas and authentic problems (*Knowledge Building Principle 1*). The results of the questionnaire are detailed in Figure 8. Questionnaire data indicated that 15 out of 20 participants disagreed with the statement that Knowledge Net creates an easy environment for creative and personal work around idea development and sharing. One interviewee commented that he experienced a sense of user frustration when locating ideas and sharing knowledge artefacts within the network. He stated, "It was hard sometimes to just find what you wanted. Even when I knew that it was there because I was the one that made it, I sometimes couldn't find it again or share it with someone else."

This key concern regarding user frustration within the networked was due mainly to a lack of organization around knowledge artefacts and ideas. Initially, the network provided an open platform where Knowledge Builders could self-organize into teams by a specific Wondering or question. However, various knowledge artefacts and developing ideas were not formally organized within the network so it was difficult to build on current knowledge or locate other network members.

Knowledge Building	**KB Inhibitor 1** Connective Efficacy	**KB Inhibitor 2** Group Identification	**KB Inhibitor 3** Knowledge Classification and Codification	**KB Inhibitor 4** Knowledge Contribution	**KB Inhibitor 5** Knowledge Self-Efficacy	**KB Inhibitor 6** Offline Interactions	**KB Inhibitor 7** Personal Identity Verification	**KB Inhibitor 8** Professional Evaluation Apprehension	**KB Inhibitor 9** System Quality
KB Principle 1 Real ideas and authentic problems			●	●				●	
KB Principle 2 Improvable ideas	●							●	●
KB Principle 3 Idea diversity			●	●					
KB Principle 4 Rise Above and scaffolding of ideas	●		●	●					
KB Principle 5 Epistemic Agency	●					●			
KB Principle 6 Knowledge community and collective responsibility		●		●					

KB Principle 7 Knowledge Building Discourse		●				●	●		
KB Principle 8 Constructive uses of authoritative sources							●		
KB Principle 9 Embedded and transformative assessment					●				

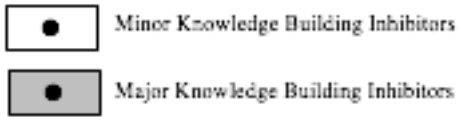

Figure 8. Impact of Knowledge Building Inhibitors on knowledge building principles

Another interviewee commented that it was not easy to retrieve a knowledge object from another Knowledge Team because there was no general classification and codification system in the network. She felt frustrated because she was not able to build on her own ideas with the ideas of others, or locate shared ideas to support her own professional learning:

> I like that anyone can come into the network and that it is open, but I found it hard to find things in there. A teacher I met at a PD [Professional Development] session told me that a group of teachers had made some literacy interventions and they were in the network. I went in to find them and searched and searched. Finally, I just asked her to send them to me by email. I think we need a way to search and retrieve things easily. I know there are good things in there, but I just can't find them.

This was an essential piece of feedback as it demonstrated an area where knowledge building was inhibited because there was no clear system for organizing new knowledge or retrieving current knowledge. In response to this challenge, three key features were developed to help organize and codify information, as follows:

To better organize the content within Knowledge Net, Alberta curricular outcomes for all subjects from K–12, as well as the ten competencies developed by Alberta Education, were added as key searchable components. An internal tagging system was then created to organize and link knowledge artefacts and ideas to specific curricular outcomes, competencies, and topics. A high-powered search feature called Elastic Search was also developed for the tool to facilitate easy searches through all the knowledge objects and files within the network by a key word, or group of words (see Figure 9).

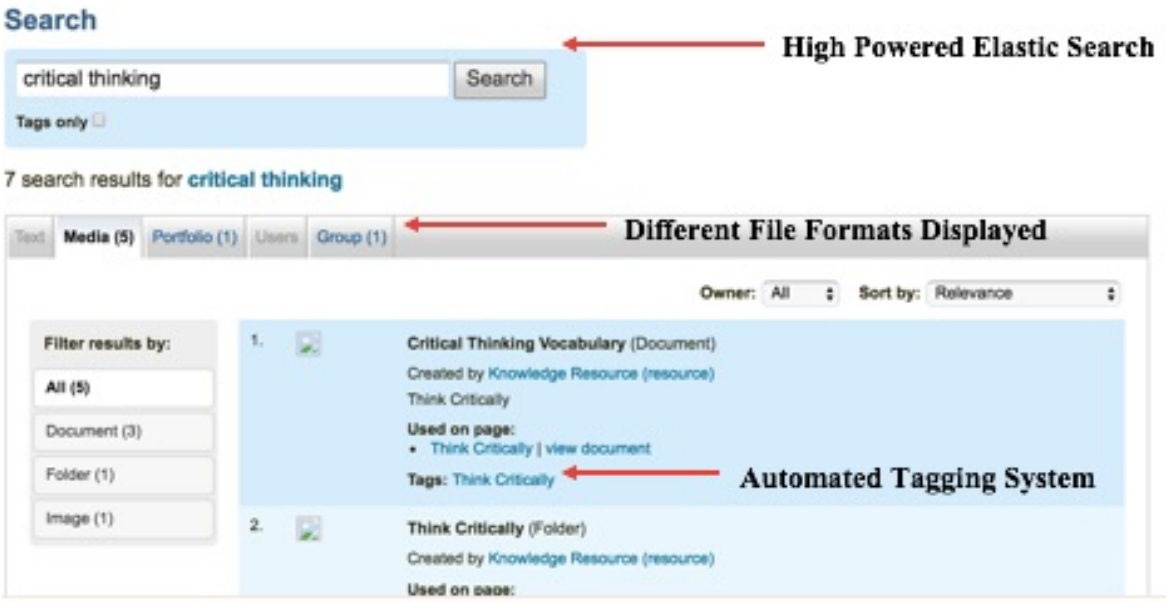

Figure 9. Elastic Search within Knowledge Net.

The Elastic Search enabled users to search by outcome, competency, topic, file type, or tag to easily retrieve knowledge artefacts and ideas. For example, if a network member searched for "critical thinking," the results presented in Figure 9 would be displayed showing the knowledge objects available, as well as the type of files and tags associated with the topic.

During the interviews, three out of five participants commented on the time needed to organize shared content. One participant indicated that she felt that the organization and codification of the content needed to be at a network level so that the users within the network would not feel burdened and overwhelmed with the task of classifying and coding network content. She said,

> I found it difficult to find the ideas I had created and also some of the work of my group. It was annoying that there wasn't an organizational way to put things into the tool so that we could find our work again.

The inability of the tool to support the coding and classifying of information not only made it difficult for users to find their knowledge products, but it also required them to spend their own time organizing and classifying their knowledge products. According to Kankanhalli, Tan, and Wei (2005), there is a direct relationship between the codification effort required by network users within an electronic knowledge repository and the use and contributions of network members. Therefore, a tagging and coding system was developed that would classify new knowledge throughout the network by subject, grade level, outcome, and specific topic without the assistance and effort of Knowledge Builders.

Offline interactions. The second area where participants felt that knowledge building was impacted was with regards to asynchronous interactions and the development of epistemic agency (Scardamalia, 2002). Effective knowledge creation requires a high level of epistemic agency, or the ability for all knowledge members to feel that they are free to put forth their own ideas, while negotiating the personal ideas of others to sustain effective knowledge advancement. In the questionnaire, 17 out of 20 participants disagreed with the statement that higher-level knowledge processes such as conjecture, wonder, and hypothesis were effectively supported within Knowledge Net as the initial building blocks for idea development. All five of the interviewed participants indicated that they felt that only working within a virtual environment often impacted the sharing and advancing of new knowledge because trust and a sense of community was difficult to establish. One participant commented that face-to-face interaction was necessary for effective knowledge building because it allowed group members to build trust together and set goals for knowledge work:

> I think one of the key pieces that we needed was to build some trust together. We all knew of each other within the division, but we had not worked together as a group.

> Initially, when we got together in the tool it was a little awkward. I was sharing things and trying to build things, but I was worried that the other people in my group thought I was criticizing their work, which I wasn't. We needed face-to-face time to just make connections as teachers and decide together where we were headed as a group.

In their research on virtual online communities Koh, Kim, Butler, and Bock (2007) identified a strong link between knowledge development and ongoing offline interactions. They found that offline interactions reinforce relationships and commitments between community members, encouraging the ongoing sharing and development of knowledge. This was reflected in my pilot study, as both professional learning communities made the decision to have offline meetings during their two district collaborative days to develop a connection with each other, establish group norms, and advance the knowledge work of the community. Following the recommendations of the participants I ensured that a blended model was supported where Knowledge Teams could meet online and offline during the research study to strengthen individual connections and build relational trust.

Evaluation apprehension. Scardamalia (2002) emphasized that effective shared knowledge building requires a high level of collective responsibility where co-constructed knowledge is freely shared with other members within a knowledge building community. A major knowledge building challenge identified by most of the participants (16 of the 20) was the inability for ideas to be improved by other teachers because they were worried that their ideas or knowledge artefacts may be critiqued or evaluated by other members within the network. During one interview session, a participant clearly articulated the hesitation she felt with regards to sharing her ideas within the network: "This was a real struggle for me. When I didn't know who anyone was in the tool I was really self-conscious about what I put in there."

The fear of being judged by your colleagues for your contributions has been found to impact the level of knowledge sharing within a professional community. Ardichvili, Page, and Wentling (2003) found that *evaluation apprehension* negatively influences knowledge sharing because online community members are afraid of possible criticism or ridicule about the items they share or post and therefore avoid idea sharing. The ability for users to decide when an idea is ready for sharing could alleviate some of the evaluation apprehension that may be felt by certain network members. In response to this feedback, an Idea Sharing Status Toolbar was created for the network. This status toolbar appears on every Idea Build and allows Knowledge Teams and individual Knowledge Builders to indicate if an Idea Build needs further help with development, is in progress, or is ready to share within the network (see Figure 10).

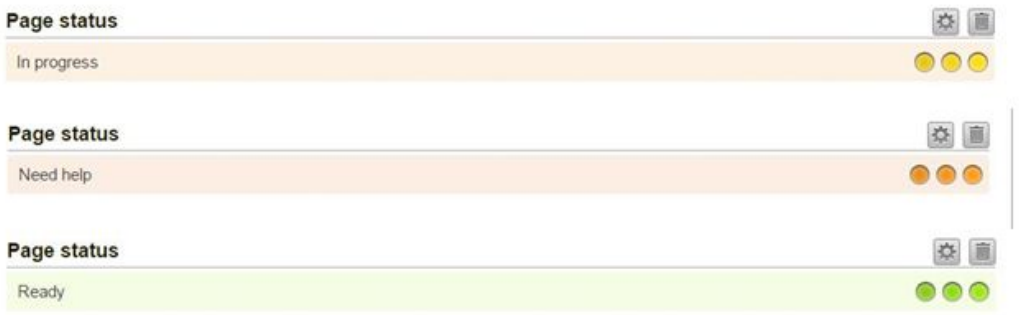

Figure 10. Idea Sharing Status Toolbar.

The introduction of the Idea Sharing Status Toolbar provided Knowledge Teams with professional autonomy to seek help when needed, work together within a Knowledge Team, and share an artefact with the general network community when they felt it was ready.

Personal identity verification. One of the key components of knowledge creation is the Constructive Use of Authoritative Sources (*Knowledge Building Principle 7*). Access to

feedback from experts and other Knowledge Builders related to the ideas and artefacts within the knowledge building network supports the continual advancement of ideas and innovation. It is important that members within the network can continually advance and develop ideas by accessing current research findings and authoritative sources.

In the questionnaire, 11 out of 20 participants strongly disagreed with the statement that they could easily identify or connect with authoritative sources in the network. Three out of five interviewees indicated that a main authoritative source they would draw on within the network would be other teachers and their expertise in certain subjects or topics. However, it was difficult to access teachers within the network because there was limited knowledge about other network members. During the interview session, one participant commented on the need to know more about other network members and their areas of interest and specialization:

> I think it would be good to know who is in there. I guess I just want people to know who I am and where I am coming from and I want to know the same. Just better matching up of people. Like Knowledge Net dating, we can find best matches and share our expertise in the tool.

Initially, the tool that was developed allowed participants to enter the network by either posting a Wondering to the general network or joining a Knowledge Team. The only identifier attributed to a Knowledge Builder within the network was a username. Four of the interview participants (n=5) commented that as more users enter the network and begin to create Knowledge Teams and post general Wonderings, it would be beneficial to provide opportunities for network members to create a personal profile. One interview participant commented that a profile page would allow members to assess both authoritative sources within the network as well as build relationships with other members who share a common subject area, expertise, or

location. The ability for network members to connect with one another and have more information on different members' areas of interest and expertise would further support knowledge building in the network.

Ma and Agarwal (2007) suggested that personal identity verification is important with regards to online interactions and knowledge sharing. First, knowledge acquisition is more efficient when knowledge contributors are identifiable. This allows other knowledge seekers to assess the credibility of the ideas and knowledge shared within the network. Second, identity verification and personal profiles provide opportunities for network members to build relationships with members who share similar interests or expertise. Finally, personal identity verification provides opportunities for future knowledge reciprocation because it allows Knowledge Builders to develop a reputation within the network as an expert in a certain area or a person who is interested in creating and sharing knowledge about a specific topic.

To address the need for network members to better assess authoritative sources within the network and build relationships, a Knowledge Builder Profile Page was created. This new page allowed individual network users to create an individual profile that included a brief introduction, a personal profile picture, and include an indication of the school at which they are currently working with a list of their teaching subjects and areas of interest. Figure 11 provides an example of a Profile Page in Knowledge Net.

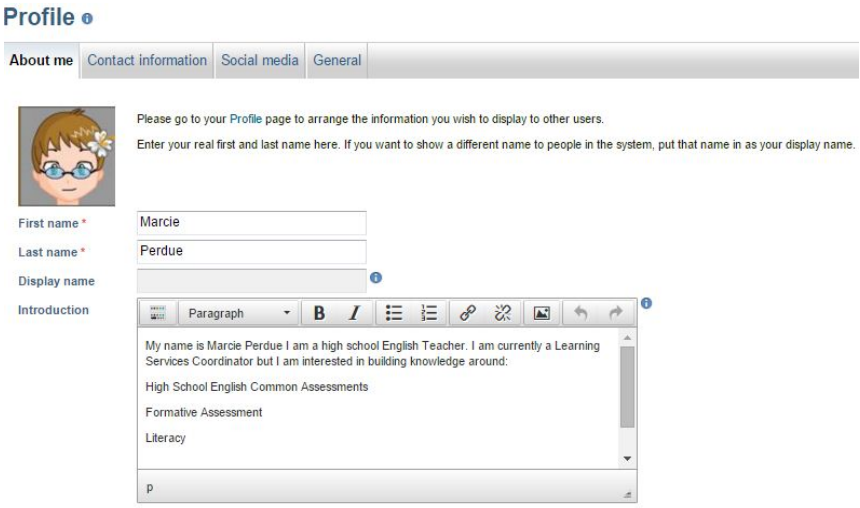

Figure 11. Example of a Knowledge Net Profile Page

Knowledge self-efficacy. Both embedded and transformative assessment (*Knowledge Building Principle 8*) within a networked environment help advance knowledge by identifying problems with new knowledge construction as well as fine-tuning current ideas to further support shared knowledge creation. The questionnaire data indicated that 13 participants felt that the tool did not effectively provide opportunities for internal assessment of knowledge artefacts from the knowledge building community. The ability to provide participants with tools to assess various ideas and knowledge artefacts is a key component of developing *knowledge self-efficacy* within the network.

When members of a network share knowledge or ideas that others deem as valuable or useful within the network they develop knowledge self-efficacy and gain confidence as a valued Knowledge Builder. According to Constant, Sproull, and Kiesler (1996) knowledge self-efficacy is positively related to the advancement of knowledge within a network because network members see that their knowledge contributions and ideas make a difference to the work of other Knowledge Builders and Knowledge Teams.

To better support the development of knowledge self-efficacy through embedded and transformative assessment, two main tools were developed within the network. The first is an Artefact Assessment Ticket and the second is a "like" feature within every Idea Build. When knowledge ideas and artefacts are shared within the network, Knowledge Builders can now attach an Artefact Assessment Ticket to any shared idea or Knowledge Artefact (see Figure 12).

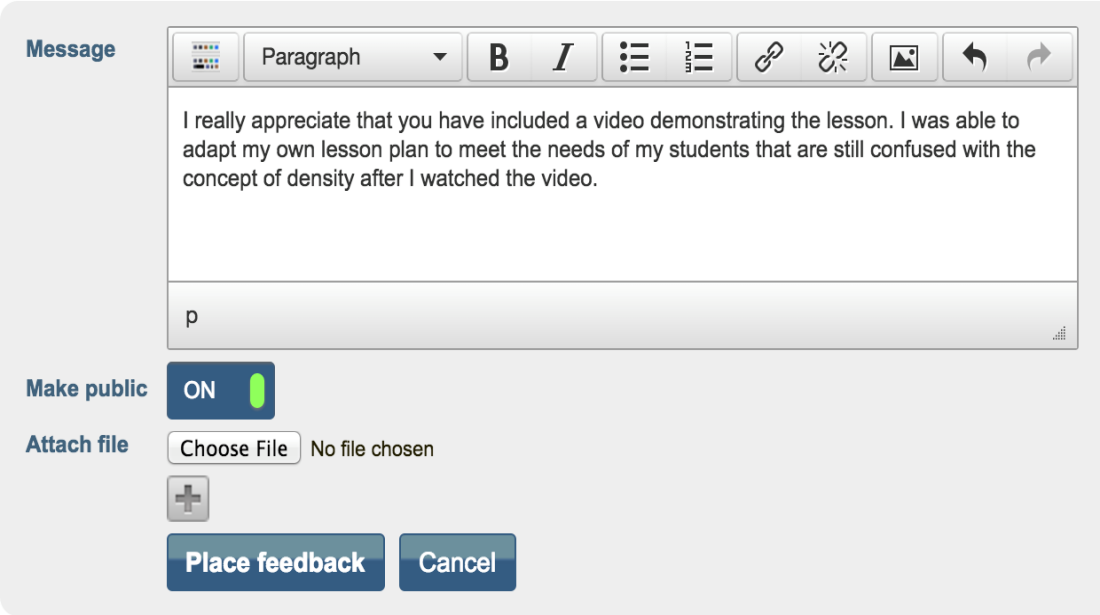

Figure 12. Artefact Assessment Ticket.

Knowledge Builders not only can "like" an Idea Build or Knowledge Artefact, but they also have the option of providing additional comments. These tools will hopefully support the development of *knowledge self-efficacy* within the networked environment and provide a variety of opportunities for network members to acknowledge the valuable knowledge contributions of other Knowledge Builders as well as provide important feedback to further develop and strengthen ideas and knowledge within the network.

Minor Knowledge Building Inhibitors. Four minor inhibitors were also identified from the pilot study data. These inhibitors did not have a major impact on the network or the shared

knowledge creation among teachers; rather, they were considered to disrupt the flow of knowledge creation and are discussed further in the following section, along with the resulting design response for Knowledge Net: 1) connective efficacy, 2) group identification, 3) knowledge contribution, and 4) system quality.

Connective efficacy. Sharing information and building new knowledge requires a system that allows users to easily retrieve previously shared knowledge and contribute new knowledge. Effective knowledge creation networks need to allow users to easily connect and communicate with each other, while also providing a robust database that can store and organize Knowledge Artefacts. Once a network can easily support knowledge contributions, users can retrieve precious knowledge items and use them as stepping stones to build and co-construct new knowledge.

Connective efficacy refers to an individual's belief that other people can use contributed knowledge and it can be can easily retrieved within the network (Kalman, Monge, Fulk, & Heino, 2002, p. 131). For connective efficacy to develop, network members must feel that their contributions are of value to other network members. Kalman et al. (2002) found that if contributors in a network are identifiable, then users with reputations for high task-relevant expertise will likely feel that their contributions will be more valuable.

Initially, the teachers in Knowledge Net were anonymous, which made it difficult for network members to discern who was a high contributor with expert knowledge within the network. This made it difficult to connect with Knowledge Builders and develop connective efficacy across the network. The data from the pilot study questionnaire indicated that most participants (18 out of 20) agreed that Knowledge Net effectively provided opportunities for teachers to sort and organize Wonderings and posts so that discussions of interest are easily

found, but a key feature that was missing from the tool was the ability to connect Wonderings, Idea Builds, and Knowledge Artefacts with other individual Knowledge Builders. The addition of a profile page allowed network members to identify specific knowledge contributors so they could easily join and extend ideas in the network. The profile page also identified Knowledge Builders who had similar expertise in specific subject areas or grade groupings, which supported an increase in the connective efficacy of the knowledge building community.

Group identification. Group identification is defined as an individual's sense of belonging and positive feeling towards an electronic networked environment (Chiu, Hsu, & Wang, 2006). In the context of knowledge sharing and creation, there is no clear consensus in the research literature about the impact of group identification and effective knowledge sharing. Ma and Agarwal (2007) found no direct relationship between been group identification and its impact on knowledge contribution in the context of virtual online communities. However, in a survey administered to 310 members of a professional virtual online community, Chiu et al. (2006) found that group identification directly impacted the quality and quantity of knowledge sharing within an online community. They also found that individuals who identify with a group perceive an additional pressure to comply with group norms of knowledge sharing, and receive intrinsic benefits when helping others. Additionally, as individuals identify more with a group, their motivation moves from one of self-interest to one of group interest, and reciprocal sharing and knowledge creation increases. Therefore, creating mechanisms within the digital tool to allow individuals to join groups, and identify themselves as a group, will better support shared knowledge creation.

The digital tool currently has a feature that allows network members to form and join teams around ideas and individual Wonderings. When the tool was not organized by curricular

outcomes, 14 of the 20 participants disagreed with the statement that Knowledge Net provides opportunities for ideas to be linked and shared with other members of the knowledge building community. A feature was created in the digital tool that allowed teachers to self-organize into groups around an area of interest. When teachers could organize their teams around curricular content areas and create their own groups, the number of Knowledge Teams within the network increased from 11 to 32.

Knowledge contribution. According to Cabrera and Cabrera (2002), the amount of knowledge contributed by individuals and groups within a networked environment increases when: 1) interactions among participants are frequent and durable, 2) participants are easily identifiable, and 3) there is sufficient information available about specific individual actions. Initially, when teachers entered the network there was no mechanism for creating a personal identity and the tracking of ideas and knowledge contributions was not available. Without a system for tracking interactions, teachers were not able to connect with one another to share Knowledge Artefacts and this prevented the development of a collective community where users could easily contribute knowledge.

To better support knowledge contributions, the Knowledge Builder Status Page was created to provide a record of the current Knowledge Teams that a member was involved in throughout the network, including a list of the current Idea Builds developed by individual teachers. A feature was also developed for network members to connect with other Knowledge Builders and follow various Idea Builds by adding them to a personal watch list. Individual teachers can also post recent Idea Builds or shared artefacts on individual Knowledge Builder Walls (see Figure 13).

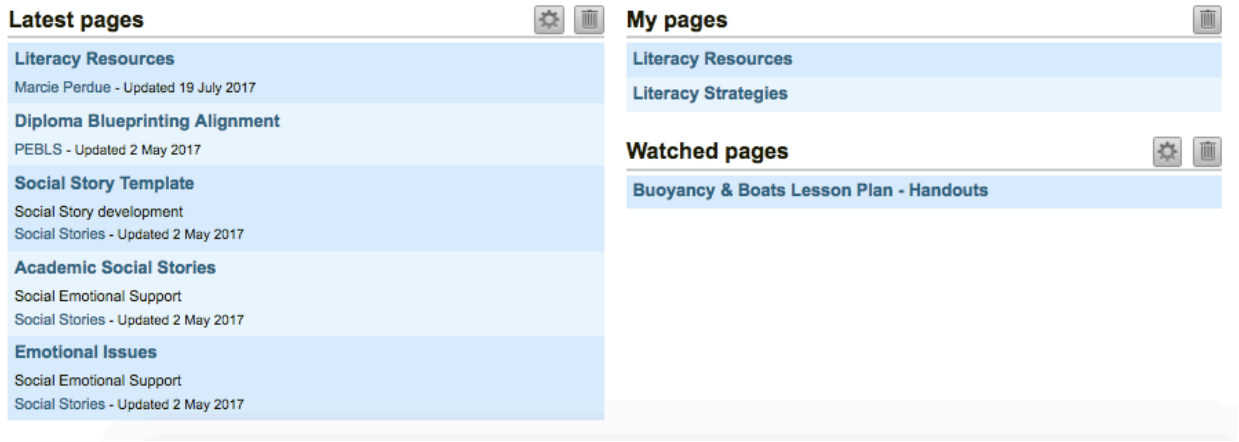

Figure 13. Knowledge Builder status example.

To provide additional information about the connections, actions, and contributions of individual teachers, the Knowledge Builder status page was created for individual teachers to more easily connect with other teachers and track the work and knowledge contributions of other network members.

System quality. Among the many variables that may cause people to accept or reject the introduction of new technology, a key determinant that has been identified within the research that is important to effective system quality is the *perceived ease of use* of the technological tool. Perceived ease of use refers to "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, p. 320). Potential users may see the benefit of using a digital tool, but if the system is too difficult, not reliable, or is too labour intensive on the user side, these all become barriers for successful system adoption.

Knowledge sharing in a networked environment is contingent upon the effectiveness of the tools available to share and develop ideas among various members. A knowledge building network is perceived as inadequate if it impedes communication among members or constrains knowledge building activities. Regardless of how motivated a teacher may be to share and co-

construct knowledge with others, if the tool requires a great deal of user effort or the knowledge building tools within the system are not adequate to meet the needs of the user, little sharing or knowledge creation may occur.

Ongoing feedback from participants was used to inform the development and modifications to the digital tool to ensure that the system was meeting the needs of the network members. I found that clear and comprehensive professional development regarding the tool and its use was critical to its successful adoption. Ensuring that teachers felt the tool was easy, accessible, and reliable was important for the continuation of further knowledge sharing and creation.

Chapter Summary

The results of the pilot study identified nine Knowledge Building Inhibitors and affirmed that knowledge creation is a highly personalized process. This chapter outlined the revisions and enhancements made to the digital tool to support a more personalized knowledge building experience. Teachers also wanted to know the authors of the various Knowledge Artefacts shared within the network, so they could provide valuable feedback and connect with other teachers to develop and improve ideas. The addition of a Knowledge Builder Profile Page and Knowledge Builder Status Page also supported the feedback provided by participants that knowledge sharing and creation is negatively impacted in spaces where personalization is limited, or personal identity verification is absent. Initially, the features within the digital tool supported anonymous participation in the network. After the modifications were made that supported a greater level of personalization within the network, participants in the research study were provided more opportunities to share and create knowledge. In Chapter 5, I report on the implementation of the research study and its findings.

CHAPTER FIVE: FINDINGS

This chapter presents the findings from the implementation of a teacher professional knowledge building network. The first part of this chapter provides a brief introduction to the four Knowledge Builder Profiles selected for further analysis. These vignettes provide a description of each teacher's experience, subject area, and grade level taught. A summary of each teacher's main source of professional learning has also been provided as well as the teacher's rationale for joining the network.

The second part of the chapter presents the data from the implementation of the case study. All findings are presented in relation to four phases of knowledge creation outlined in the conceptual framework (see Chapter 2).

- Phase I: Wonderings
- Phase II: Joining Knowledge Teams
- Phase III: Idea Building
- Phase IV: Artefact Sharing and Assessment

Due to the iterative nature of knowledge building, some findings overlap into other phases. These replications of findings are discussed in detail to better illustrate the relationships and connections that occurred among the four phases of knowledge creation.

Four Knowledge Building Vignettes

The four Knowledge Builders (educators) profiled in this case study are from the same district, but different schools. They represent four different levels of teacher expertise and provide a cross-representation of teaching experience, grade levels, and subject areas taught. In each vignette, a pie graph (see Figures 14, 15, 16, and 17) illustrates the level of participation for

each teacher within the network according to the four phases of knowledge creation. Each participant has reviewed and approved their Knowledge Builder Profile.

Joe. Joe is a 25-year veteran teacher, considered by his teaching colleagues to be an expert in high school humanities. Joe teaches in a larger high school with seven other humanities teachers. He is the subject lead for the English department at his school and he is also responsible for sharing division learning with the entire school staff.

Joe has been teaching at the same high school for 13 years and focuses mainly on high school English. He has participated in marking provincial diploma exams and has also been a member of various provincial curriculum working groups. Joe's main source of professional learning is the division-wide professional learning community (PLC), and he actively connects with his PLC members and encourages new staff in his department to join the various divisional collaborative days. Joe is interested in exploring math resources as he has recently been assigned a junior high math class. He joined Knowledge Net to collaborate with other teachers with the hope that together they could encourage and motivate each other to build resources that would improve student learning. A graphical presentation of Joe's participation in Knowledge Net is provided in Figure 14.

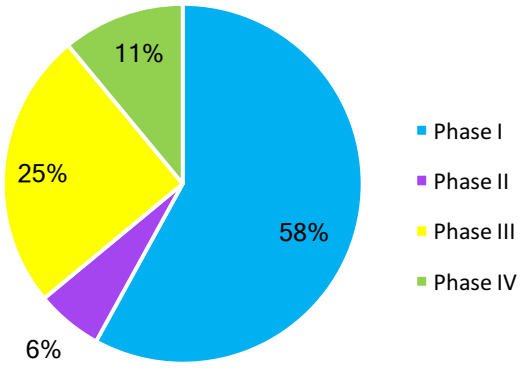

Figure 14. Knowledge Net participation (Joe)

Katie. Katie is new to the teaching profession. She recently graduated from university and this is her first year teaching a grade 2 class in a small rural school. She is the only grade 2 teacher in her school and is keen to connect with other more experienced teachers in the division to improve her own professional practice. Katie is part of the division's mentorship program and considers this to be her main source of professional learning. As part of the first-year mentorship program, Katie attended four days of professional learning at division office with her mentor teacher and has also been provided two collaborative days to build and shared resources with her mentor. Katie is also a member of the grade 2 division professional learning community and connects often with her PLC members for advice, support. and content knowledge of grade 2 curriculum. Katie's profile is presented in Figure 15. Katie joined Knowledge Net so that she could meet other teachers in the division and build her skills.

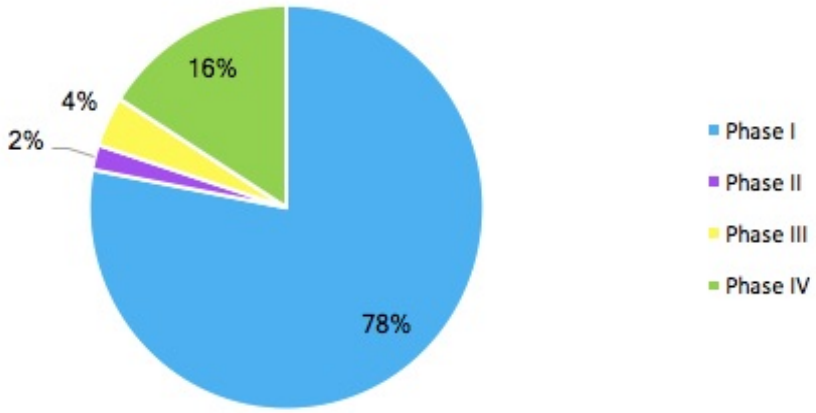

Figure 15. Knowledge Net participation (Katie)

Bill. Bill is a second-year teacher who is new to the school division. His teaching focus is in inclusion and he works mostly with educational assistants to support the autistic students within his school. Bill often collaborates with the other teachers in his school and his administration relies heavily on him for specific expertise and knowledge regarding specialized programming supports. Bill regularly seeks the advice of shared service providers (e.g., speech pathologists, educational psychologists, and occupational therapists) and considers them to be his main source of professional learning. Bill is also the lead for the division PLC on inclusion and is a member of various division committees that focus on inclusive education. Bill's main reason for joining Knowledge Net was to help other teachers with inclusive education programming and individual student supports. A profile of Bill's participation in Knowledge Net is presented in Figure 16.

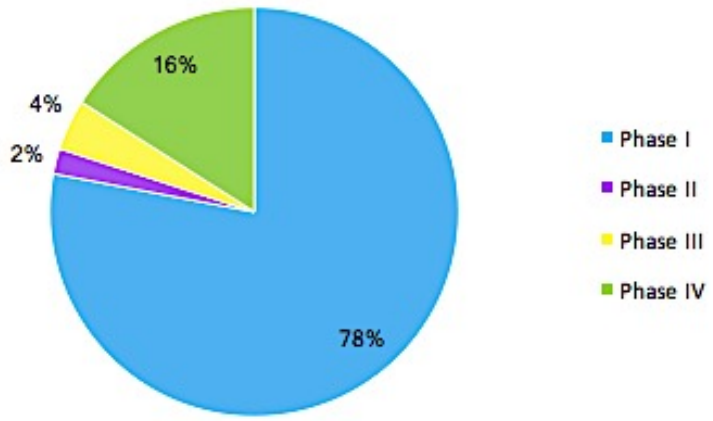

Figure 16. Knowledge Net participation (Bill)

Maggie. Maggie is a sixteen-year master teacher responsible for both grades 7 and 8 science at her rural school. She is the only junior high science teacher in her school and has been teaching at the same school for twelve years. She is well versed in her program of studies and is

continually changing her practice and lesson materials to better prepare her students for high school science. Maggie focuses on inquiry based learning in her classroom and much of her class time is focused on lab work with her students. The main source of her professional learning has been attending large provincial science conferences and focused junior high science sessions offered by her nearby regional consortium. Her school division offers four PLC days where she could meet with other teachers across the division in her grade and subject group, but Maggie prefers to work within her school during these days to improve her own individual teaching practice. Maggie has recently been asked to teach a grade 8 social studies class and is interested in joining Knowledge Net to access materials and resources to help her prepare for this new subject area. Maggie's Knowledge Builder Profile is illustrated in Figure 17.

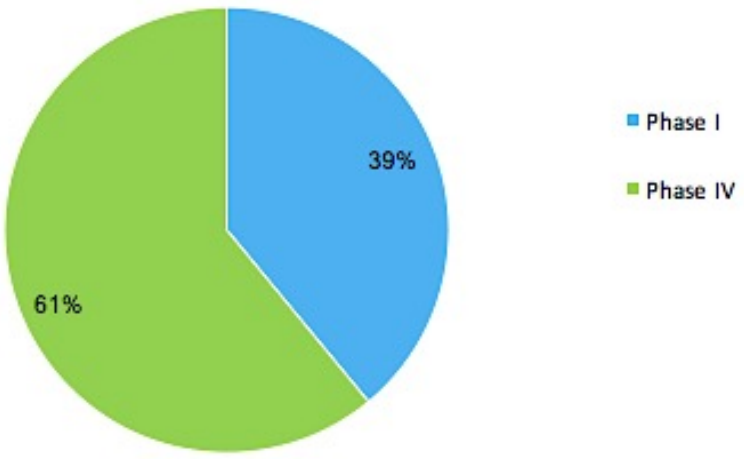

Figure 17. Knowledge Net participation (Maggie)

These profiles will be used throughout this chapter to develop *the story of knowledge building* and provide personal experiences of specific teachers in the network. The remaining sections of this chapter focus on the four phases of knowledge creation and present findings

related to the following three themes that were identified from the analysis of the data: 1) Interactions, 2) Knowledge Building, and 3) Knowledge Barriers. In order to organize and clarify the findings for this case study, a data display was created that presents the major findings for each phase of the conceptual framework (see Figure 18).

Phase I: Wonderings

In Phase I of the conceptual model, a Wonderings Discussion Forum was developed to create an open environment that would support pervasive idea generation and collaborative inquiry. In this first phase of knowledge creation, teachers entered the network and posted individual Wonderings that introduced new ideas, concepts, and challenges within their professional practice.

Multiple data sources were collected during Phase I to better understand the collaborative processes and interactions needed to support effective collaborative inquiry in the Wonderings Discussion Forum. Analysis of individual teacher Wonderings formed the primary source of data and provided insight into the kinds of interactions and features teachers needed to support sustained idea exploration. The application of social network analysis allowed further investigation of the complex interaction patterns that developed among teachers and an examination of questionnaire data illustrated the initial knowledge building experiences of teachers and their perspectives regarding collaborative inquiry.

Interactions. The interactions involved while teachers explored, linked, and scaffolded individual Wonderings in the discussion forum were analyzed using server log data and social network analytics.

Phase I: Wonderings

Expertise	Number of Wonderings Posted	Number of Wonderings Read	Number of Wonderings Linked	Number of Wonderings Scaffolded
Novice	1494 (27%)	911 (32%)	154 (37%)	5 (3%)
Apprentice	1530 (28%)	947 (34%)	113 (27%)	14 (12%)
Specialist	1821 (33%)	645 (23%)	111 (27%)	13 (34%)
Master	561 (10%)	259 (9%)	33 (8%)	27(39%)
Expert	91 (2%)	61 (2%)	5 (1%)	5 (100%)

Phase II: Joining Knowledge Teams

Expertise	Number of Knowledge Teams Joined
Novice	33
Apprentice	13
Specialist	27
Master	7
Expert	4

Expertise	Number of Teachers
Novice	9
Apprentice	11
Specialist	16
Master	9
Expert	5

Phase III: Idea Building

Expertise	Number of Idea Builds Created	Number of Idea Builds Shared
Novice	25	5
Apprentice	17	11
Specialist	48	15
Master	29	7
Expert	10	6

Phase IV: Knowledge Assessment & Artefact Retrieval

Expertise	Number of Knowledge Artefacts Retrieved	Number of Feedback Tickets
Novice	118	9
Apprentice	107	9
Specialist	118	5
Master	239	4
Expert	24	2

Figure 18. Key findings across the four phases of knowledge creation

The following log files were extracted from the network to measure the asynchronous discussions within the Wonderings Discussion Forum: 1) number of Wonderings posted, 2) number of Wonderings read, 3) number of Wonderings linked, and 4) number of Wonderings scaffolded. These measures illustrated the initial knowledge building discourse practices that occurred in the network (see Table 6).

Table 6

Wondering posted, read, linked, and scaffolded by level of teacher expertise

Teacher Expertise	Number of Wonderings posted	Number of Wonderings Read	Number of Wonderings linked	Number of Wonderings scaffolded
Novice	1494 (27%)	911(32%)	154 (37%)	5 (3%)
Apprentice	1530 (28%)	947 (34%)	113 (27%)	14 (12%)
Specialist	1821 (33%)	645 (23%)	111 (27%)	13 (34%)
Master	561 (10%)	259 (9%)	33 (8%)	27 (39%)
Expert	91 (2%)	61 (2%)	5 (1%)	5 (100%)

The participants in this case study used their allocated division professional learning time to focus on specific knowledge building within the network. A high level of engagement with posted Wonderings and Wonderings read within the network demonstrated a strong level of idea diversity and exploration among teachers, whereas a low percentage of discussion forum participation indicated a lack of engagement in collaborative inquiry or knowledge building discourse. An examination of the server data found that novice, apprentice, and specialist teachers were active in the discussion forum, but master and expert teachers rarely contributed or developed ideas.

At a more interactional level, the log data for individual Wonderings indicated that the linking and scaffolding of Wonderings to form higher Idea Builds increased in relation to teacher expertise. For example, although the number of Wonderings posted was relatively high for novice teachers, these Wonderings were rarely used to scaffold into Idea Builds (three percent). Conversely, while only five of the 91 Wonderings posted by expert teachers were linked by other network members, 100 percent of these linked Wonderings were scaffolded into Idea Builds and developed into some of the highest levels of shared knowledge created in the network. The connection between teacher expertise and successful knowledge building was a major factor that impacted effective knowledge sharing in the network and will be discussed in multiple findings throughout all four phases.

Social network analysis. Social network analytics were also used to examine the patterns of relationships and interactions between and across network members. An important measure of interaction and individual influence within the network is degree centrality. In network analytics, an individual is represented by a dot called a node and various connections and interactions with other individuals are represented by a line called an edge or tie. Degree centrality refers to the number of ties a node has to other nodes. Individuals that have more ties in a network have higher interactions and more opportunities to share and build knowledge. To pictorially demonstrate the degree centrality of the network, a radial sociogram was developed that illustrates teacher level of expertise by using colour-coded nodes and increased nodal size to indicate network members who have a high degree of centrality. The sociogram in Figure 19 illustrates that novice, apprentice, and specialist teachers were actively engaged in idea exploration,

while the expert teachers remained disengaged. This is clearly illustrated by the pink dots that sit on the outlying circumference of the radial diagram.

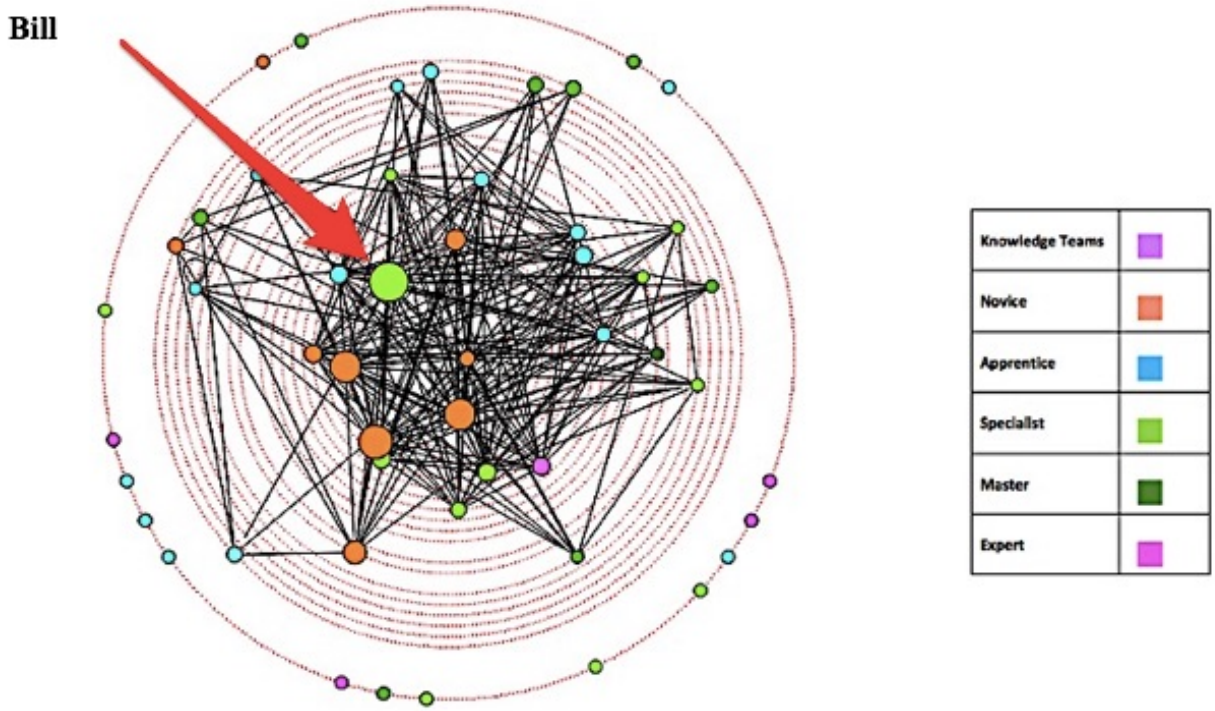

Figure 19. Radial depiction of Wonderings Discussion Forum by teacher expertise

A larger nodal size within the sociogram indicates teachers who are animators within the network community. For example, Bill represents an influential network actor who has multiple edges (interactions) connected with other members. The various edges connected to Bill represent the numerous Wonderings he posted in the network (296) that provided the stepping stones to larger Idea Builds. One of the main findings from the data analysis was that higher levels of teacher expertise indicated a lower degree of centrality in the discussion forum and key animators such as Bill initiated and supported idea development.

Findings from the data also indicated that the motivation for teachers to initiate sharing and developing knowledge together changed according to the level of teacher expertise. Ten out of 14 teachers who self-identified as master and expert teachers indicated in the *My Wonderings Participant Questionnaire* that the discussion forum did not provide an effective area for them to extend the edges of their current understanding of various professional challenges. Instead, the majority of these teachers (nine out of 14) chose to enter the network because of a shared artefact that they felt could improve their practice.

Another social network indicator from the server data was the level of *betweenness* among various Knowledge Builders. Betweenness determines the extent to which an individual is a conduit of information between other network members. If information flow within the network is often indirect and certain network members consistently direct or disseminate information to other members within the community, they would have a high average betweenness.

The following sociogram is a visual view of the betweenness average of various network members. Again, nodal size was used to clearly identify those members of the network who had a high degree of betweenness centrality (see Figure 20).

Both Bill and Katie had a high degree of betweenness and were key players in the network for encouraging active participation among other network members and building relationships and interactions that further strengthened the discussion forum. Bill acknowledged that his position in the network was instrumental in moving conversations forward and connecting teachers within the network.

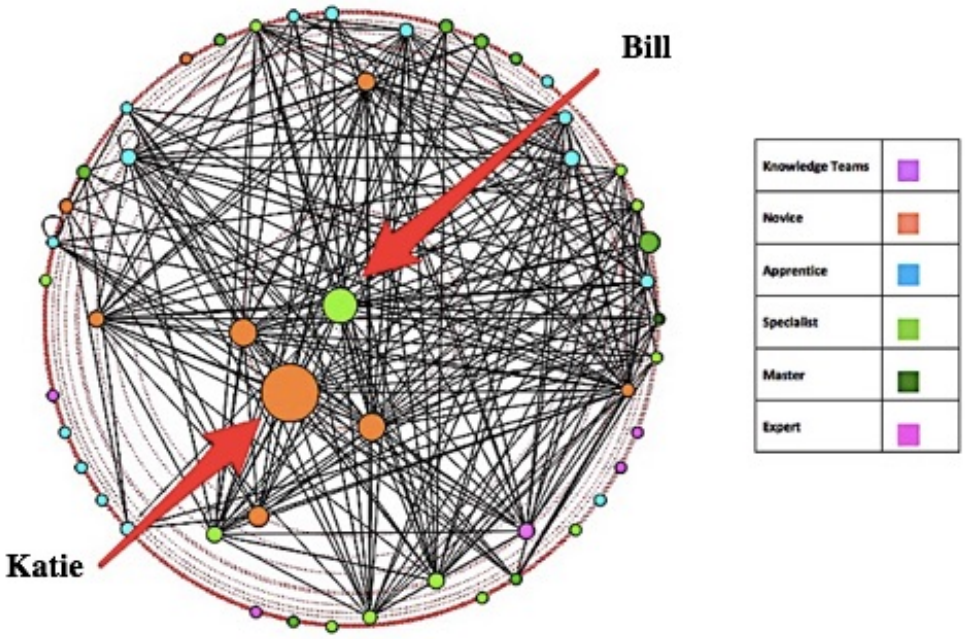

Figure 20. Radial depiction of network inbetweenness.

Bill said, "I always made sure to answer questions in the Wonderings Forum that I knew I had expertise in and tried to connect other teachers with one another so that we could have a dialogue." After analyzing the development of ideas throughout the network, I found that those Knowledge Builders who held a high degree of betweenness increased and improved the development of shared knowledge. Often these Knowledge Builders became key animators of the network and assumed leadership roles within Knowledge Teams to initiate shared knowledge building. This is contrary to previous research (Scardamalia, 2002) that suggested that a high degree of betweenness would interrupt or impede effective knowledge building.

Knowledge building. A sense of collective responsibility and pervasive idea generation is necessary for the initiation of shared knowledge building. Data from the *My*

Wonderings Participant Questionnaire (see Appendix C) indicated that most participants (32 out of 50) agreed with the statement that the Wonderings Discussion Forum promoted knowledge building. A closer analysis of the content in individual posts helped me to gain a comprehensive understanding of the development of collective knowledge in the discussion forum. To determine the amount of knowledge constructed within the Wonderings Discussion Forum (see Table 7), all individual Wonderings were coded using Gunawardena, Lowe, and Anderson's (1997) *Interaction Analysis Model for Examining Social Construction of Knowledge in Computer Conferencing,* which is based on social constructivist principles and negotiating processes.

Table 7

Interaction analysis of knowledge construction coding labels

Level	Description	Number of Posts
1	Sharing and Comparing of Information	2344 (42.6%)
2	The discovery and exploration of dissonance or inconsistency among ideas.	1070 (19.5%)
3	Negotiation of meaning/co-construction of knowledge	1341 (24.3%)
4	Testing and modification of proposed synthesis or co-construction	693 (12.6%)
5	Agreement statement(s) applications of newly constructed meaning/ideas.	346 (0.06%)

An analysis of the coded Wonderings revealed that 42.6 percent of all posts focused on the sharing and comparing of information. These discussions contained single messages posted by teachers stating an opinion, asking and answering individual questions, and agreeing with the posted Wonderings of other network members. These posts represented the lowest level of knowledge construction, but they also contained key social processes that developed a sense of community within the Wonderings Forum such as encouragement of other Knowledge Builders, praise for Wonderings that were posted, and acknowledgement of strong Wonderings or ideas that resonated with other network members. Together, these posts formed the initial building blocks of the network community and created a sense of belonging for network members.

Another key area of engagement within the discussion forum that developed and supported knowledge building discourse was the number of posts that demonstrated the negotiation of meaning and the co-construction of knowledge (24.3 percent). In these posts, teachers expressed differing opinions on various subjects and moved discussions to higher levels of idea exploration. For example, in one discussion thread, three network members negotiated the use and relevance of a sound chart as a literacy intervention. The following is an example of this discussion:

> P1: I am thinking that a focus on phonics might really help these students with severe learning disorders. Does anyone have resources that might support this? I need them at a pretty low level, but for a grade 8 student.
>
> P2: I was thinking the same thing, but I don't want to put elementary work in front of these junior high kiddos.

P3: I was recently introduced to the concept of a sound chart where students put a picture that is meaningful to them next to a sound. Maybe this could be something we use. Keeps it personalized and age appropriate.

P1: I like this concept, what a totally different perspective on phonics. Thanks!

These three participants later joined a Knowledge Team and constructed a sound chart template as an Idea Build that they used for their literacy students. This online exchange demonstrated the network's ability to effectively support teacher knowledge building through pervasive problem solving.

Divergent viewpoints and sharing of expertise was often required to develop effective solutions to various pedagogical challenges posed in the network. Teachers coming together in the forum to explore and wrestle with various professional challenges presented a key motivator to participate in the network and the Wonderings Discussion Forum provided a flexible and asynchronous platform that supported sustained idea exploration.

Analysis of the data also revealed that the Wonderings Discussion Forum was the main area teachers chose to share authoritative resources on current professional practice. Of the 5497 total Wonderings posted, 318 contained evidence of idea improvement by connecting various Wonderings to literature, current research, and student learning data. These posts contained shared journal articles, links to key resource sites, and updates on current professional learning opportunities. Teacher responses in the questionnaire (32 out of 50) also reflected the value of the Wonderings Discussion Forum for providing multiple opportunities for teachers to share outside resources that promoted continuous knowledge building. The ability of the digital tool to connect various authoritative

sources to linked and scaffolded Wonderings provided teachers with opportunities to integrate current research and data into Wonderings and to improve ideas shared within the network community.

The data from the discussion forum indicated that the digital tool supported effective knowledge building by creating a strong foundational platform to support the initial exploration of various shared ideas. The forum also supported collaborative problem solving among teacher Knowledge Builders and effectively integrated the authoritative sources from individual posts to other higher-level Idea Builds. However, the data also presented several Knowledge Barriers that impacted the initiation of knowledge building within the Wonderings Discussion Forum.

Knowledge building barriers. While it was encouraging to see that the Wonderings Forum supported idea exploration, collaborative inquiry, and constructive use of authoritative resources, barriers to knowledge building impacted the collaborative exploration of ideas.

A total 5497 Wonderings were posted in the network. This suggests that the discussion forum was active and that participants were generally involved in shared idea exploration. However, when the forum posts were collectively grouped by level of teacher expertise, patterns emerged with regards to the purpose of the discussion forum and initial knowledge building behaviours (see Figure 21).

The number of Wonderings posted and read by novice, apprentice, and specialist teachers demonstrated a high level of engagement in idea sharing and exploration. Conversely, master and expert teachers rarely posted in the forum or read the posts of other network members.

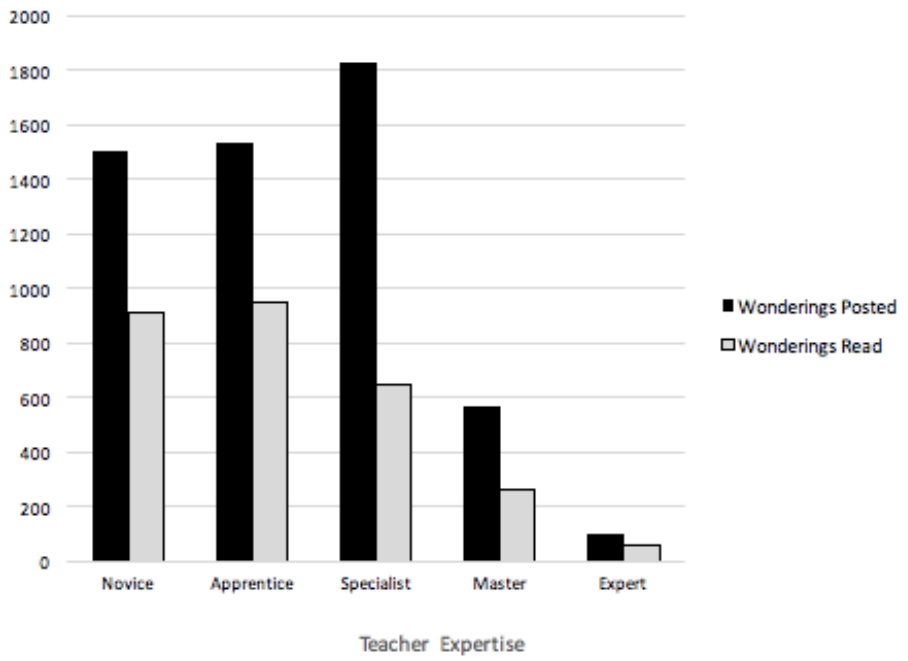

Figure 21. Number of Wonderings posted and read by level of teacher expertise.

An analysis of the responses of master and expert teachers in the *My Wonderings Participant Questionnaire* revealed that 13 of the 14 teachers strongly agreed that the retrieval of new teacher resources was the main reason for entering the network and connecting with other teachers. Joe's response is indicative of this:

> I liked the shared artefact section; it provided me with some great resources and that was initially what got me in there. I also had a clear purpose for joining the network and I already knew who my key go-to teachers were from my connections in the division PLC, so I didn't see the need to post any Wonderings. I just wanted to form a Knowledge Team and get to work.

While master and expert teachers focused on the retrieval of shared teacher resources as an invitation to collaborate and join Knowledge Teams, teachers who were

new to the profession (e.g., Katie) found that the discussion forum provided an opportunity to hear a variety of opinions related to specific content areas as well as to connect with other teachers. Katie said, "I like that I could post a Wondering in the network and that I would get a community of teachers responding with various backgrounds and expertise." While most novice and apprentice teachers actively engaged in the discussion forum, the absence of interactions from the more experienced teachers made it difficult for collaborative knowledge building to develop and idea generation to be sustained because specialized knowledge was often absent from the discussions.

Further analysis of online posts illustrated that the network community had difficulty moving to higher levels of knowledge construction through the linking and scaffolding of various individual Wonderings. This could be related to participants having multiple purposes for entering the discussion forum as mentioned above, but network data also indicated that most of the posts among participants (88 percent) were teacher-to-teacher responses rather than a group of teachers scaffolding and building a continuous dialogue. These results indicate that while teachers were successful in posting and connecting individually with one another in the network, the lack of reciprocity to read posted notes and link and scaffold upon other's ideas impacted the ability of the network to initiate the beginning stages of shared knowledge creation.

The lack of knowledge integration could also be attributed to teachers feeling disconnected within the network, and this may have impeded their ability to scaffold ideas and join Knowledge Teams. The data from the *My Wonderings Participant Questionnaire* aligns with the server data. It indicated that more than half of participants (56 percent) felt that a sense of community was lacking within the discussion forum and

that the discussion area rarely extended the edges of the knowledge building or the community's collective understanding.

Results from the questionnaire data indicated that 28 out of 50 teachers felt that members were not encouraged to join Idea Builds by other members and, therefore, there was little sense of community within the discussion forum. The development of relationships and network connectedness will be discussed in Phase II of the data findings, but it is important to note that the inability to form relational trust and strong online interactions within the Wonderings Discussion Forum impacted the ability of teachers to develop strong discursive structures that supported continuous collaborative inquiry.

In summary, Phase I of the conceptual model focused on building strong network interactions that formed the foundational building blocks of shared knowledge creation. Analysis of the data suggests that while the Wonderings Forum supported idea exploration and collaborative inquiry, network members focused mainly on teacher-to-teacher interactions and a sense of community was not consistently developed.

Phase II: Knowledge Teams

The focus of Phase II of the conceptual model is the creation of Knowledge Teams that work on specific scaffolded Wonderings or Idea Builds. To better understand the interactions and knowledge building principles within the Knowledge Teams, three sources of data were analyzed: Social network analytics within a selected Knowledge Team, responses from the *Knowledge Team Participant Questionnaire*, and interview responses. The data from these main sources are discussed in relation to three themes: interactions, knowledge building, and knowledge barriers.

Interactions. The various interactions within Knowledge Teams were organized into two main interaction patterns: 1) Weak Periphery Interactions and 2) Knowledge Creation Leaders and Information Brokers. These patterns demonstrated effective network behaviours that supported ongoing shared knowledge building within Knowledge Teams.

Pattern one: Weak periphery interactions. Teachers engaged in collaborative inquiry and initiated idea sharing in the Wonderings Discussion Forum. At the beginning stages of Knowledge Team development, teachers often chose to become independent peripheral observers rather than collaborative Knowledge Builders. At this stage, there was little interaction or connectivity between team members. Instead, some teachers chose to watch what others in the network were doing rather than engage in the initial discussions or exploration of ideas. Many of these teacher observers were the expert and master teachers, who were often not engaged in joining Knowledge Teams. Figure 22 provides a visual depiction of the patterns of interaction among core and peripheral network members. Each teacher is represented by a dot that is colour-coded according to their level of expertise. The Knowledge Teams in the network are illustrated by a purple dot and the lines represent the connections of various teachers to Knowledge Teams in the network. The central area of the sociogram illustrates sustained interactions that occurred between teachers that formed several Knowledge Teams and indicates the highest level of activity in the network. Moving outward, various outliers of the network community are shown. These represent those who chose initially not to join Knowledge Teams, but instead watched while teams developed and focused on various Idea Builds.

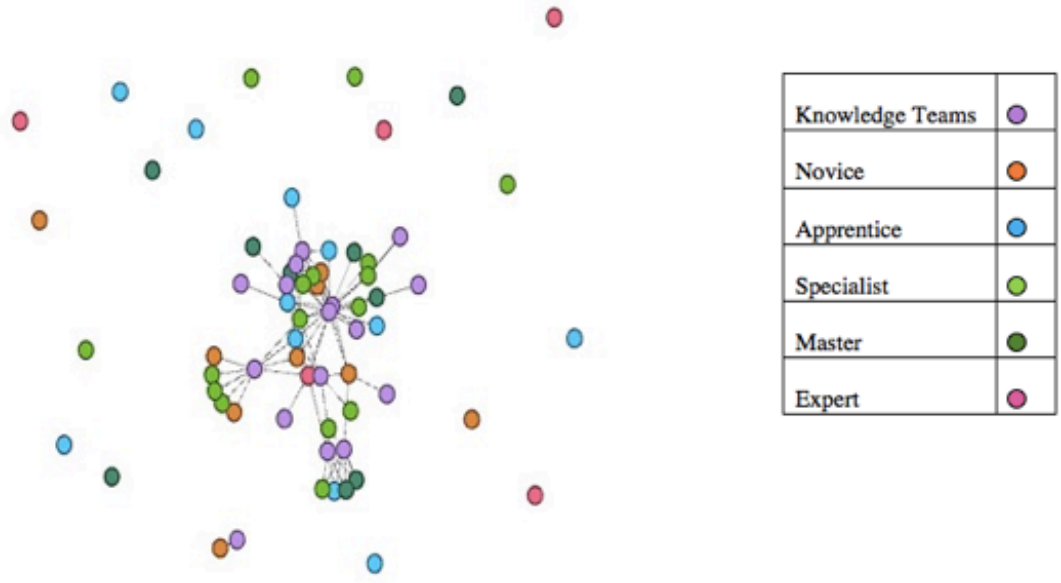

Figure 22. Patterns of interactions between core and peripheral network members.

The lack of participation by the outlier teachers at the beginning of group formation impacted the distribution of expertise within the network and the development of higher-level Idea Builds. Because the network was an open environment, teachers could see the development of ideas throughout the network. Bereiter (2002) emphasized that an essential component of knowledge building "is making ideas explicit and public so that they serve as conceptual artefacts" (p. 270). As individual Knowledge Builders began to connect personally with other network members or found specific Idea Builds that related to their professional practice, they joined Knowledge Teams and began to share their explicit knowledge of teaching. However, most expert (four out of five) and

master teachers (five out of nine) remained at the weaker stage of peripheral interactions throughout the case study.

Server log data indicated that 100 percent of the linked Wonderings of expert teachers in the discussion forum moved forward to become scaffolded Idea Builds for various Knowledge Teams. This suggests that the content knowledge of expert teachers was a highly sought-after commodity by other network members and often formed the essential building blocks for further knowledge creation. However, most expert teachers (four out of five) strongly disagreed with the questionnaire statement that "Knowledge Teams provided opportunities to work at the cutting edges of ideas that were of interest to me." The data from the questionnaire indicated that while novice, apprentice, and specialist teachers found the knowledge of expert teachers valuable, they themselves did not view participation in the network as meaningful and were unable to find Knowledge Teams in the network that would further developed their expertise or extend their professional practice.

Pattern two: Knowledge creation leaders and information brokers. Leaders play a fundamental role in engaging peripheral team members to participate and contribute to team ideas. Leaders and facilitators such as Joe connected and encouraged team members by facilitating discussions and recognizing individual contributions. The Knowledge Team sociogram represented in Figure 23 illustrates how Joe interacted with his four core Knowledge Teams (represented by the red diamonds), but also ensured a strong connection was made to outlier participants through individual one-to-one contact (represented by the red edges) on the sociogram.

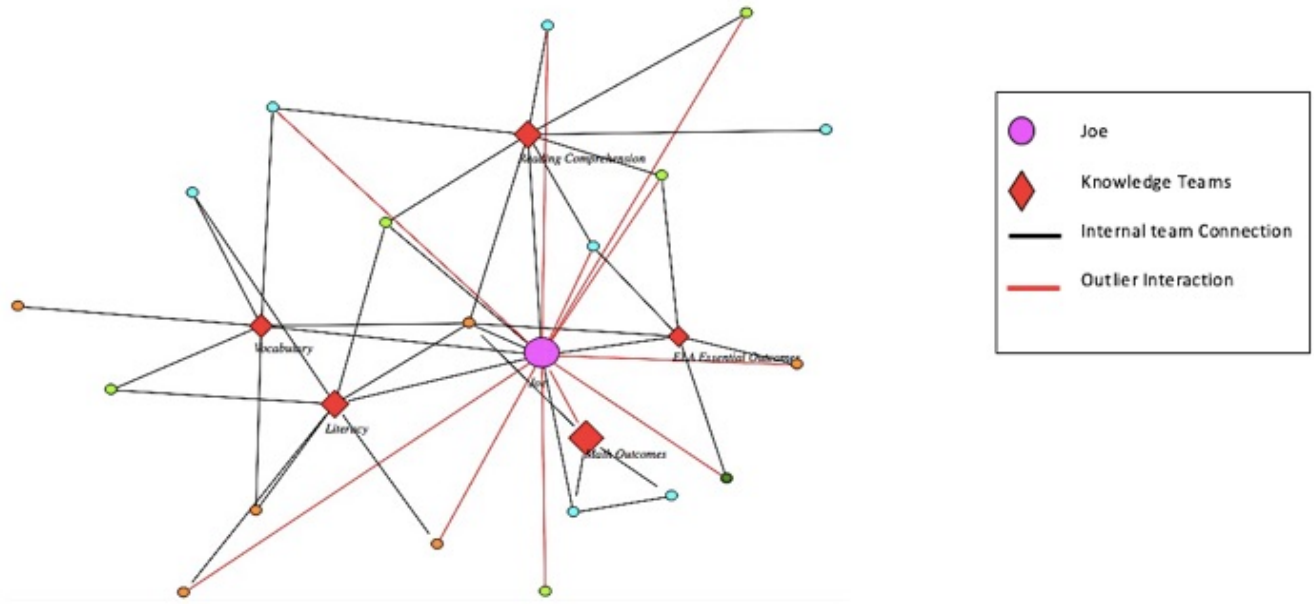

Figure 23. Sociogram demonstrating knowledge creation leadership within the network.

As a Knowledge Leader, Joe also crossed network boundaries and shared knowledge artefacts with multiple Knowledge Teams. During his interview, Joe explained how he shared resources between two Knowledge Teams: "My vocabulary team was working on word sorts that I knew would benefit the literacy team, so I asked if I could share our resources and when I got the ok, I added them to the literacy team files." This cross-pollination of ideas and resources demonstrates how knowledge becomes de-privatized by team leaders and shared across the network.

Core Knowledge Leaders can also become conduits of information within a Knowledge Team. Looking at Figure 24, we can see that Bill is central to the connections of novice teachers within the Autism Knowledge Team and has become a main broker of knowledge building discourse. The various edges that are connected to and from Bill demonstrate how information often flows through him to other members.

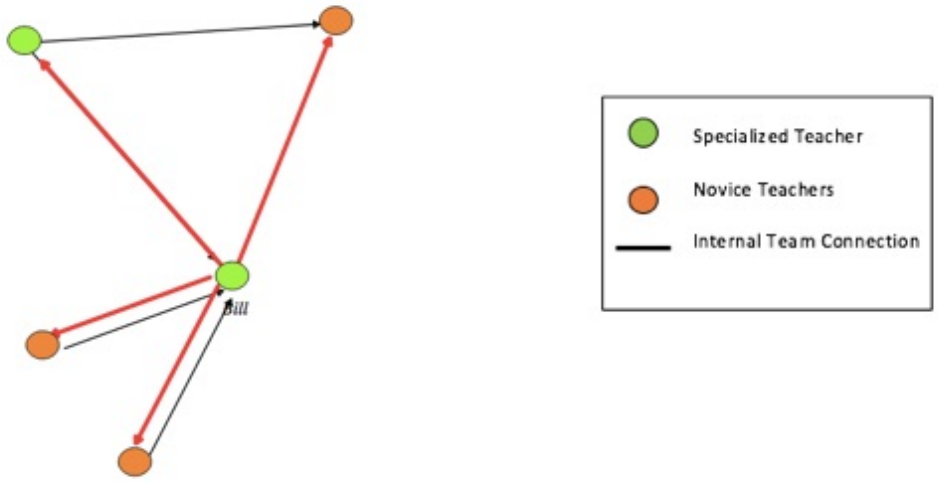

Figure 24. Sociogram demonstrating information brokerage within the network.

The sociogram indicates that Bill demonstrates a high degree of betweenness; rather than impeding knowledge building, however, his high degree of betweenness illustrates how strong leadership is required within knowledge building teams to connect members to information as well as to scaffold and build on shared ideas within Knowledge Teams. In Bill's example, leadership was essential to further develop and improve ideas because his other team members had minimal expertise and lacked specialized knowledge.

Teacher professional learning is about continuous improvement of teacher practice. The core purpose of the network was to support teachers as they shared their expertise and improved individual practice. Brokers within the network such as Joe and Bill became catalysts for development of specialized skills and expertise with other

teachers and supported the sustained improvement of ideas shared within the Knowledge Teams.

In addition to the analysis of interaction patterns within Knowledge Teams, I also examined the structures that supported knowledge building in Knowledge Teams and identified knowledge barriers that impacted successful shared knowledge creation.

Knowledge building. Creating a dynamic knowledge building community requires that teachers come together around a focused idea or area of concern. The more successful Knowledge Teams in the network demonstrated strong reciprocal knowledge building behaviours that moved away from individual resource sharing and began to develop more collaborative inquiry processes focused on the creation of shared knowledge artefacts.

To better understand the complex social dynamics that evolved during group knowledge development, a step-wise analysis was implemented to track the changes and shifts of interactions within one Knowledge Team.

Initial formation of a Knowledge Team. Early in the case study, several teachers agreed to form a Knowledge Team that focused on a key Wondering that suggested the development of a group of teachers that could share and build social stories. At first, the bulk of the work in the Knowledge Team consisted of individually-created social stories, which are represented by the black boxes in the sociogram illustrated in Figure 21. The black arrows in the sociogram indicate weak ties among various network participants where teachers shared their personally-created social stories within the team, but are not connected to other team members. The green edges in the sociogram illustrate teachers within the Knowledge Team who viewed a shared social story or downloaded the story

from the network. Notice that at this point teachers are not interacting with one another as shared Knowledge Builders, but instead are connecting and interacting only with the Shared Artefacts. This initial formation of the Knowledge Team is illustrated in Figure 25.

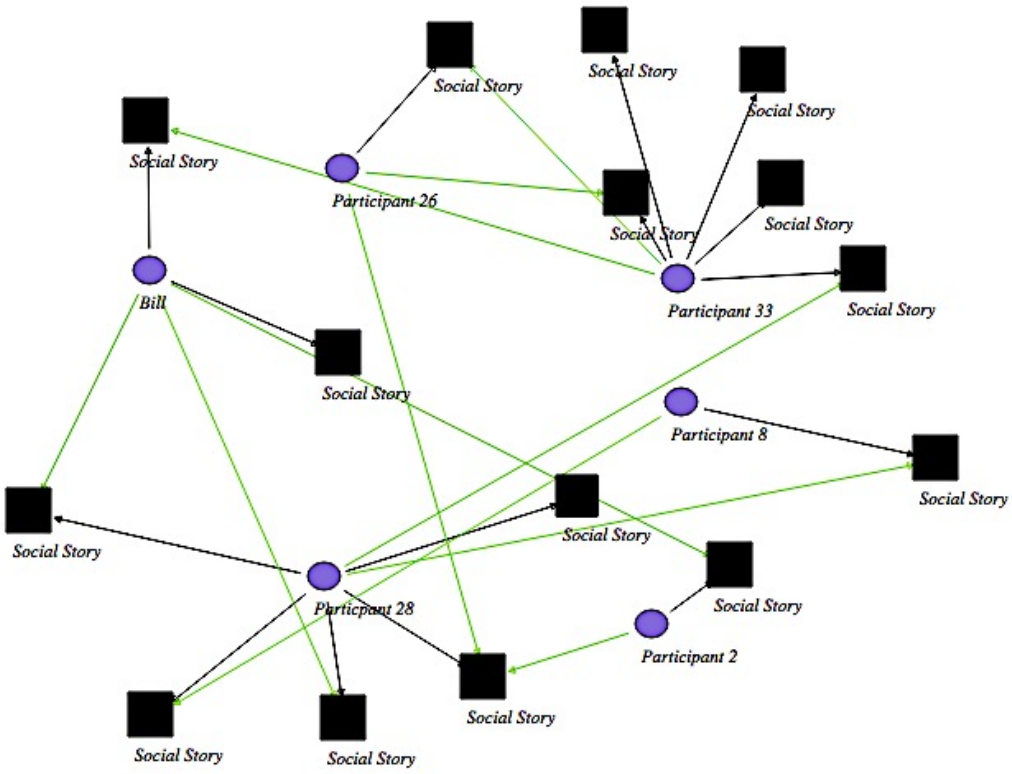

Figure 25. Initial formation of a Knowledge Team

Some Knowledge Teams were not able to move beyond this stage of initial team formation, and the team remained fragmented and functioned as more of a resource database for team members than a collective knowledge building community.

Mid-point interactions of a Knowledge Team. As Knowledge Artefacts were created and shared within the Social Story Knowledge Team, teachers began to develop closer relationships with one another and the interaction patterns changed from weak ties

(black edges) to stronger more direct ties (red edges) that demonstrated knowledge building discourse and idea sharing. This mid-point phase of Knowledge Team development is illustrated in Figure 26.

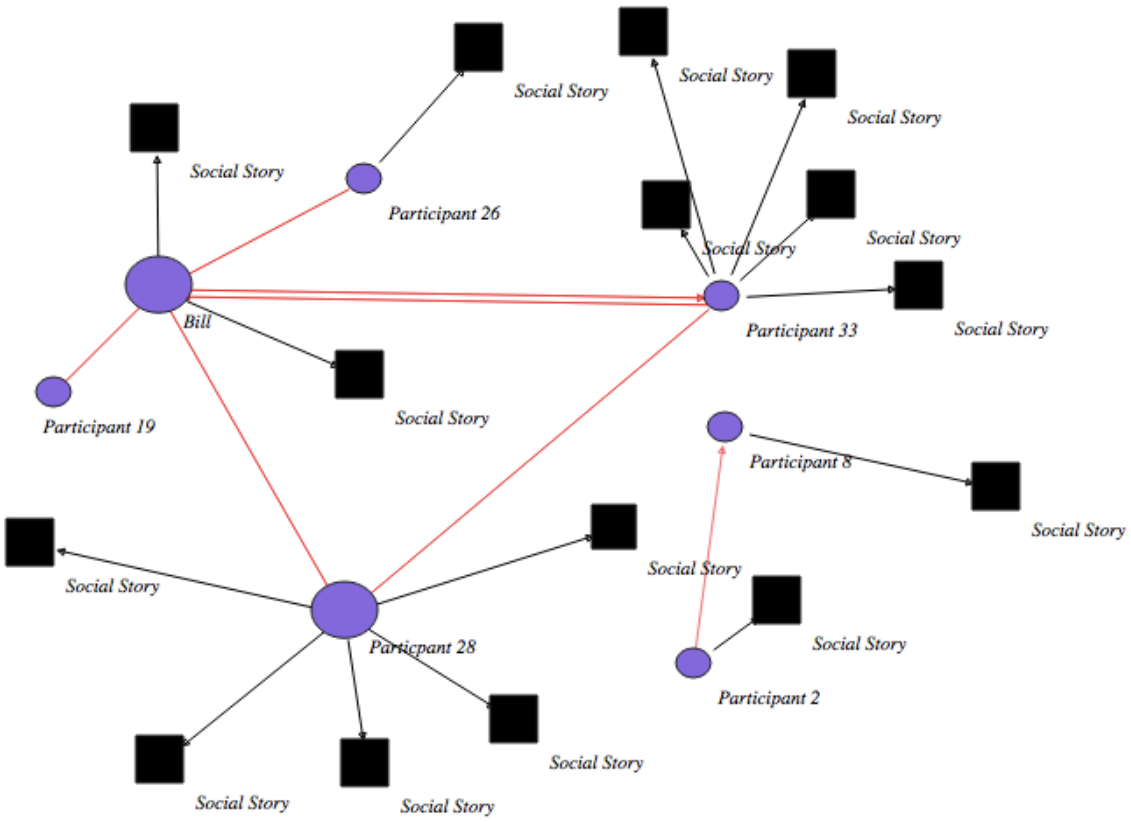

Figure 26. Mid-point interactions of a Knowledge Team

The direct ties and interactions of teachers are indicated by the red edges within the sociogram. A new Knowledge Team member, Participant 19, joined in the team interactions and shared idea development. As more teachers began to connect with one another the shape of the interaction patterns in the sociogram changed. Initially, nodes

were spread out and few edges connected group members to one another. Now, the nodes are clustered closer to the centre of the sociogram illustrating the development of a more complex and dense network community with multiple interactions among the team members. Finally, the nodal size of both Bill and Participant 28 grew, demonstrating that they became key Knowledge Leaders within the team and actively supported the development of shared knowledge creation by sustaining discourse and interactions among various team members. Their position in the network also indicates that they moved towards centralizing the knowledge of the team by connecting and re-directing the flow of information.

Final stage of Knowledge Team interactions. In the final stage of Knowledge Team formation, a strong shift occurred in interaction patterns as teachers aligned to co-construct a Knowledge Artefact. Figure 27 demonstrates how the depth and intensity of team interactions increased when team members moved from a resource collection phase to the shared construction of Knowledge Artefacts such as the Social Story Template. The blue edges in the sociogram indicate the strong ties that are directly associated with a specific Knowledge Artefact.

While there were different levels of contribution within the team and not all participants were directly connected to the Social Story Template, we can see that all team members interacted with at least one other member. Bill once again demonstrated his leadership skills as he brought both Katie and other participants who previously were not directly associated with the Social Story Template into the Knowledge Team. Additionally, the newest member, Participant 19, joined in the co-construction of the Short Story Template and multiple interactions became connected to the main Idea Build.

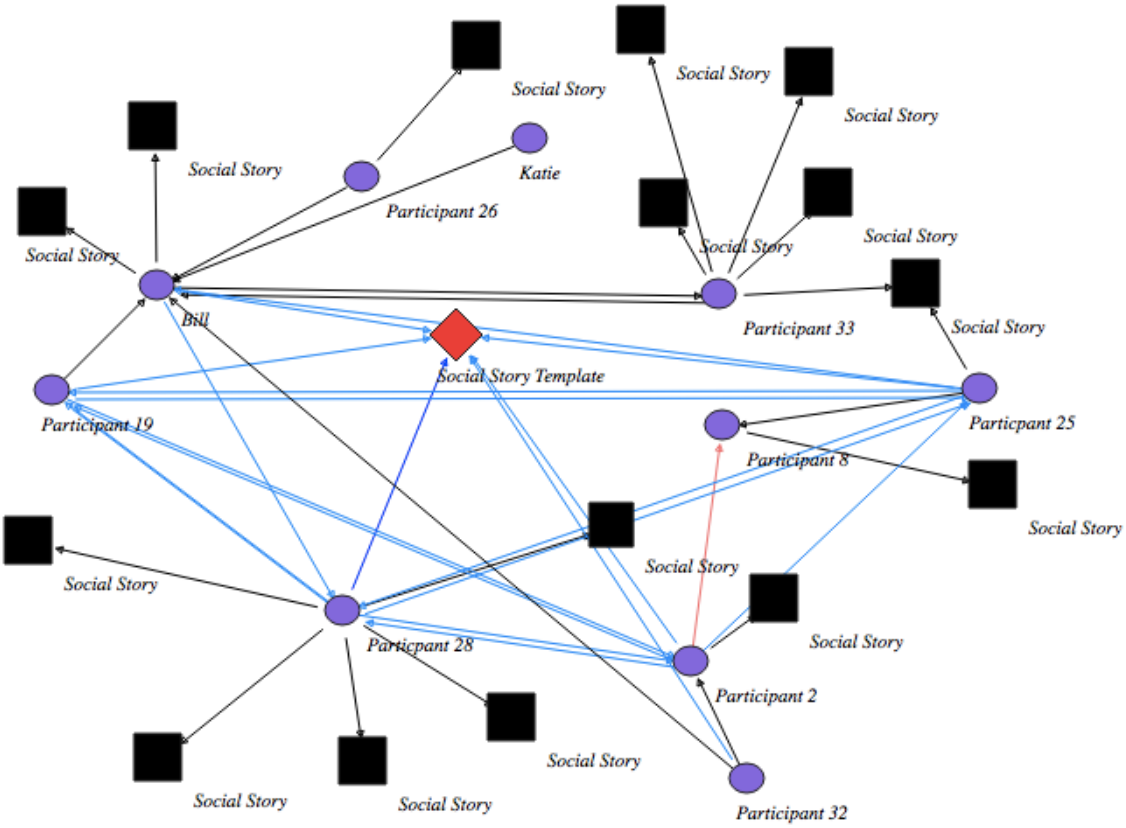

Figure 27. Final stage of Knowledge Team interactions

Again, the shape of the sociogram illustrates that more intricate and dense interactions developed between team members; additionally, strong direct ties (blue edges) illustrate that consistent, ongoing connections occurred among and between team members that were focused on the development of a central, shared idea.

Figures 25, 26, and 27 represent the development of the interaction patterns for one Knowledge Team and demonstrate how the nature and focus of individual contributions change as Knowledge Teams and interactions strengthen over time. We can see from the three sociograms that as a Knowledge Team developed, the roles,

contributions, and areas of focus moved from an individual perspective on knowledge acquisition to a shared focus on collaborative knowledge building. Some teachers, like Bill, assumed leadership roles within the knowledge building community to help support the development of shared artefacts, while others developed a more collaborative and collective focus for creating shared knowledge.

Knowledge building barriers. The examination of the Social Story Knowledge Team provided insight into the stages of effective knowledge building within a community. Further analysis of research findings also provided an opportunity to explore barriers within Knowledge Teams that impacted or inhibited collaborative and continuous shared knowledge building.

Professional status. The teaching profession is highly personalized, and teachers often define their professional identify through their subject and content areas of specialization. In this context, knowledge can be viewed as an object of power and status. For some teachers, expertise and specialized knowledge represent years of honing a unique set of content area skills that are connected to job status. Developing and sharing this knowledge with other teachers might mean a loss of status or professional identity. Some experienced teachers in the network (nine out 14) expressed hesitation in joining Knowledge Teams because they viewed the development of teacher expertise as something that is acquired through individual teacher professional development, not through collaborative knowledge sharing. According to the *Knowledge Team Participant Questionnaire* data, experienced teachers (nine out of 14) did not feel responsible for the knowledge building of other teachers in the network.

Maggie, a master teacher, explained her reluctance to join Knowledge Teams in the network:

> The best way I learned how to be a teacher was by making my own lessons and tests. I have resources that might be useful to other teachers, but I didn't want to join teams and make items for new teachers because I wouldn't be helping them become better teachers if I gave them everything.

The experience and learning involved in developing individual teaching resources such as lesson plans, student worksheets, and assessments was often viewed as a personal endeavour that was an integral component of becoming a successful teacher. Further analysis of server data also demonstrated that as the expertise of teachers increased, they were less likely to join Knowledge Teams within the network (see Table 8).

Table 8.

Number of Knowledge Teams by Level of Teacher Expertise

Teacher Expertise	Number of Knowledge Teams
Novice	33
Apprenticeship	13
Specialist	27
Master	7
Expert	4

Both master and expert teachers made up 13 percent of the total participation in Knowledge Teams within the network and a majority (ten out of 14) indicated in the *Knowledge Team Participant Questionnaire* that they did not feel a professional responsibility to share outside or personal resources with other network members to promote team knowledge building.

Relationship building. Effective Knowledge Teams require strong collaborative relationships with other teachers working within and across the network to develop Shared Artefacts. To support and develop these strong relationships, team members needed to develop relational trust and group norms that aligned and focused group work.

In schools, teachers can connect both verbally and non-verbally. For example, brief interactions in the hallway and collegial conversations build and develop trust and social bonds. In virtual environments, deep personal connections are often difficult to develop and can sometimes become barriers. Communication is handled differently in virtual environments and the use of visual cues that often develop emotional richness in face-to-face interactions are often absent in an online environment. For example, teachers can misread tone in individual posts and a sense of belonging can sometimes be difficult to develop because the social dimensions of bonding are different in network platforms. This means that communication in a virtual environment needs to be more explicit, but this can often require additional time on the user side to ensure effective and clear communication is accomplished.

Moreover, the initial foundation of relational trust needed for teachers to initiate knowledge building, especially when they are tackling professional challenges, can often be difficult to develop in an online environment. Most participants in the study (38 out of

50) commented on the need to have face-to-face interactions with their Knowledge Team members to build trust and develop relationships This aligns with the findings of the earlier pilot study, where participants found that face-to-face interactions were needed to move teams to higher levels of shared knowledge creation.

Phase III: Idea Building

The most essential phase of the knowledge creation conceptual framework is Phase III, which focuses on Idea Building. In this phase, teachers came together in Knowledge Teams to collaboratively build and develop shared knowledge. To better understand how teachers created and fostered shared Idea Building, three data sources were used: 1) server data that focused on the contributions and collective knowledge building discourse required to create an Idea Build, 2) results from the *Idea Building Participant Questionnaire*, 3) analysis of an Idea Build Dissection, and 4) interview responses. These multiple data sources were synthesized to examine the effectiveness of the different collaborative interactions and social structures present during idea development.

Interactions. Analysis of the various interaction patterns that occurred during the development of a single Idea Build within a Knowledge Team provided a visual snapshot of the coordination and collaboration required to develop higher levels of shared Knowledge Artefacts. Using the criteria outlined earlier in Chapter 3 (Collection of Knowledge Objects), a Mathematics Idea Build was selected for further examination and analysis.

Over the course of this research, a group of teachers came together to share, build, and advance their knowledge of mathematics. As these teachers moved from the

Wonderings Discussion to form a Knowledge Team, their focus moved beyond individual exploration of knowledge resources to collaborative inquiry around outcome-based math assessments. The following Idea Build analysis provides a description of one Knowledge Team's progression through shared idea development. The various discursive patterns and network structures necessary for effective knowledge creation are illustrated in three emergent stages of Idea Building: 1) Independent Knowledge Construction, 2) Collaborative Idea Exploration, and 3) Intensive Co-Constructed Knowledge Creation.

Independent knowledge construction. At the initial Independent Knowledge Construction stage of Idea Building, we can see that the teachers within the Mathematics Knowledge Team were isolated from one another and that the focus of the group was on knowledge production (see Figure 28).

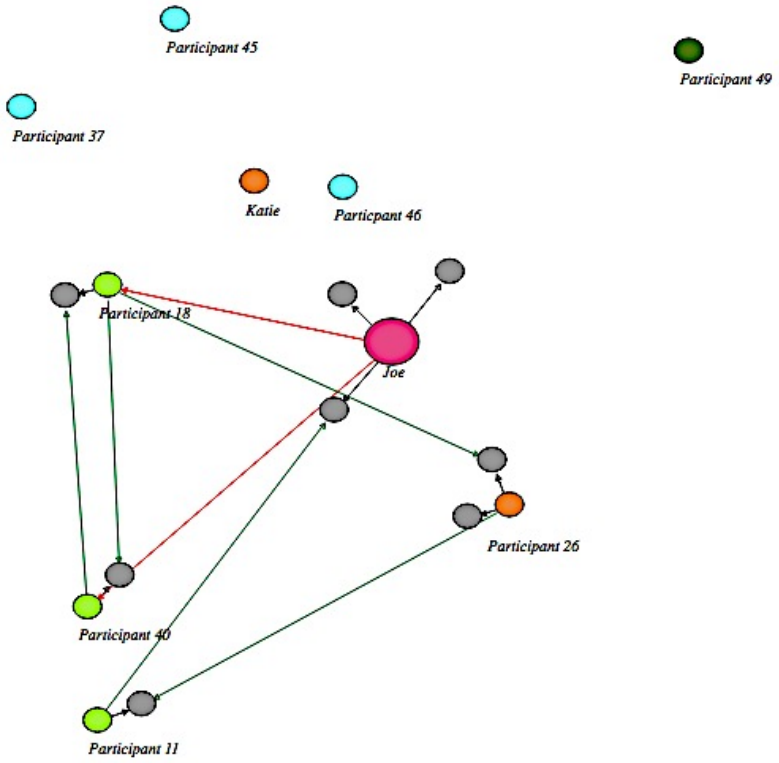

Figure 28. Sociogram Illustrating Independent Knowledge Construction

At this point, individual Knowledge Builders created resources that they shared with other team members, but most of the interactions occurred only between the Artefacts (indicated by the green edges in the group sociogram) and not team members. The focus of the team at this point was on retrieving resources shared by other group members. There was little attempt to improve or innovate these resources by the team members and no feedback was provided regarding resource development.

We also see in the group sociogram that there were still many Knowledge Builders who remained as outliers. The only Knowledge Builder who engaged in direct conversation with other group members at this stage was Joe, who was developing a few common math assessments with participants 18 and 40. For this team, the shift from *Independent Knowledge Construction* to the next stage of *Collaborative Idea Exploration* was initiated by Joe who provided the spark for the team by posting a Team Wondering inquiring if anyone was interested in developing a set of formative assessments that would check students' understanding of various mathematical outcomes. From this initial Team Wondering, several team members responded and came together to develop a shared Idea Build.

Collaborative idea exploration. One of the key emergent structures that developed within the Knowledge Teams as they moved into *Collaborative Idea Exploration* was the initiative of individual team members who connected their personal Knowledge Artefacts to Shared Idea Builds. In Figure 29, we can see how several individual math assessments (represented by the grey dots) were connected to the common scaffolded Idea Build, Math Outcome Checks (represented by the purple triangle). Instead of team members independently building and retrieving knowledge

artefacts from the network, teachers came together around a common purpose and were beginning to build on the ideas and artefacts of one another. Joe, continued to be the main information broker of the group (illustrated by a larger nodal size), bringing other participants into the Idea Build.

In this stage, we also see that new participants entered the Knowledge Team and contributed individual Knowledge Artefacts, thus demonstrating the characteristic knowledge building behaviours outlined in the *Independent Knowledge Construction Phase*.

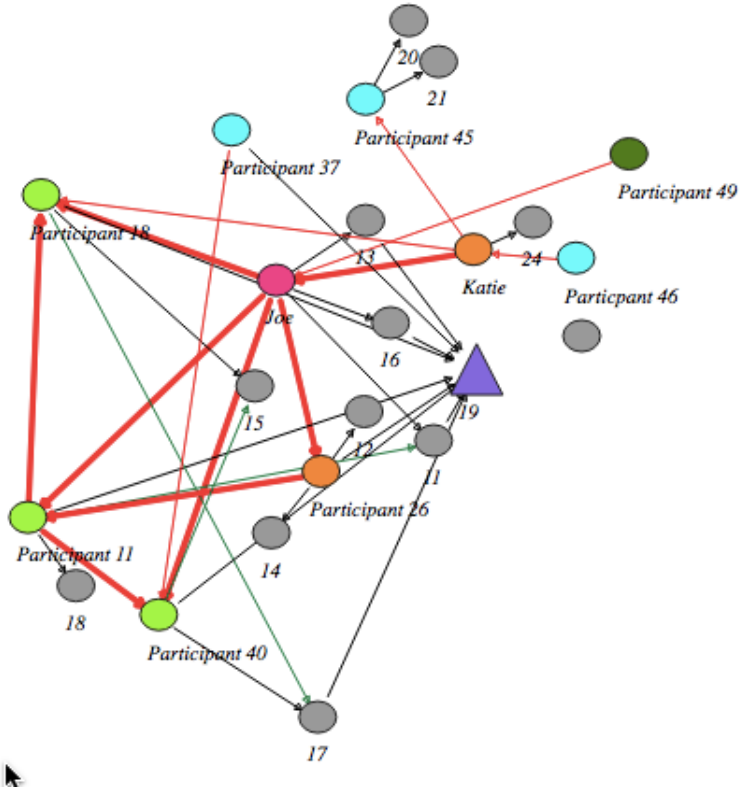

Figure 29. Sociogram Illustrating Collaborative Idea Exploration

As the team continued to engage in collaborative idea exploration, their knowledge building behaviours shifted to focusing on connecting with new team members and encouraging them to contribute to the building of a common Idea Build. For example, Participant 45 shared two Artefacts with the team and participant 46 was invited to join in a discussion thread with Joe and Katie, thus bringing him into the core inquiry of the group. Participant 49 was the only outlier who remained disconnected from the work of the other Knowledge Team members.

This stage also presents interesting interactions between and among group members as team members splintered off into smaller sub-groups around particular Idea Builds, while still contributing to the main shared Idea Build of the Knowledge Team. For example, Participants 11, 18, and 40 were all at the same school; they collaboratively built a set of mathematical assessment tools to support an outcome-based report card that was implemented within their school. This splintering apart and then recombining of Knowledge Builders advanced the knowledge of the whole group because it provided opportunities for other team members to access higher-level Knowledge Artefacts that were developed by several Knowledge Builders, and diffused different knowledge assets across the team.

As the team members began to develop various math outcome checks they also realized they needed external resources such as previous provincial exams and blueprinting templates that would provide them further information on the level and types of questions students would be asked on provincial achievement exams. As they collaboratively analyzed previous exams, the team began to move towards the co-construction of a digital tool that would formatively assess students on different outcomes

during class and provide various math strategies to students as part of their assessment feedback. This new assessment tool was developed within the Moodle plugin provided by Knowledge Net and demonstrates one of the highest levels of shared knowledge creation within the network.

Intensive co-constructed knowledge development. In this final stage of Idea Building, teachers within the Knowledge Team created a series of collaborative Google Docs that they shared within the network. These collaborative documents contained a detailed analysis of several previous provincial exams wherein various exam questions were aligned to specific mathematical outcomes. Each question was rated for level of complexity and specific mathematical strategies were developed by the team to support multiple ways of solving various mathematical problems. As the work within the network began to expand, the team agreed to meet face-to-face several times to develop the digital tool and share mathematical strategies.

At this stage, we can see that all the team members were now connected and interacting with the Math Outcomes Idea Build (represented by the red diamond on the sociogram in Figure 30. The work of the team in this stage was more purposeful and the team had a clear plan for developing and moving forward with their ideas as they were developing. Participant 49 and 46 have now become highly engaged as the work progresses and they can see a meaningful connection between the ideas within the team and their own professional practice.

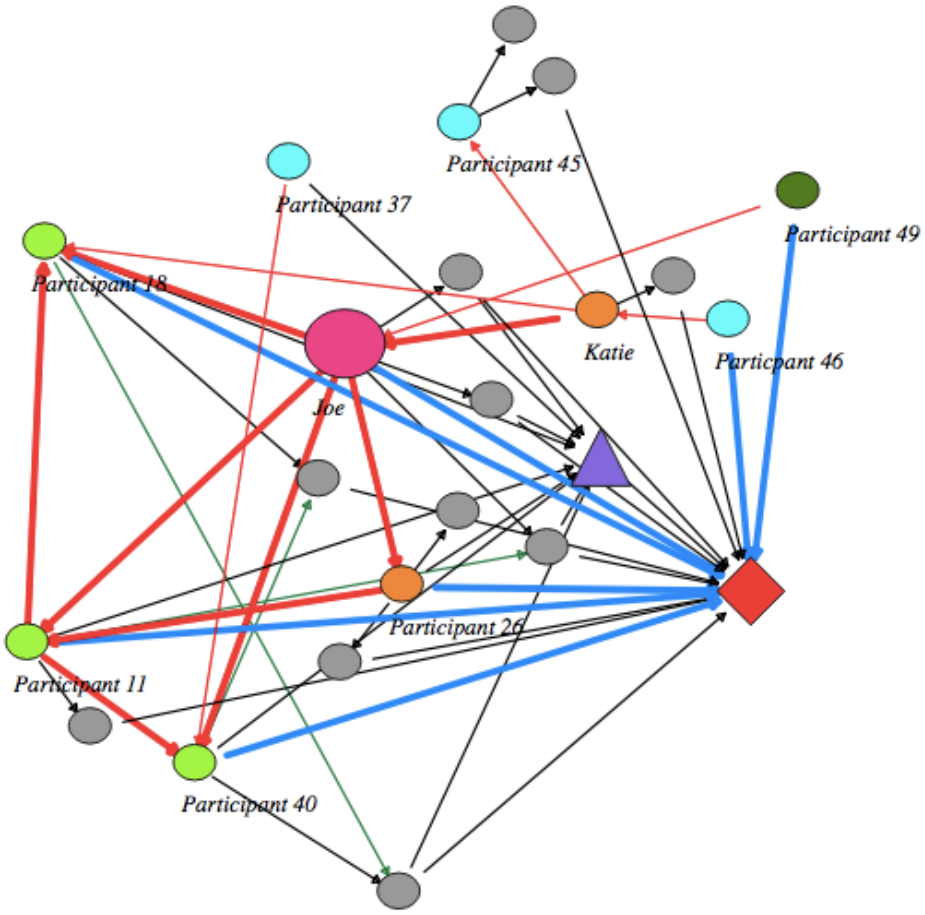

Figure 30. Sociogram Illustrating Intensive Co-Constructed Knowledge Development

Data analysis was also conducted on the members of the Knowledge Team to determine the level and complexity of team members' interactions over the three stages of the Idea Build. Figure 31 demonstrates the development of collective cognitive responsibility of the Knowledge Team and the deeper knowledge building discourse and collaboration among teachers as their Idea Build evolved.

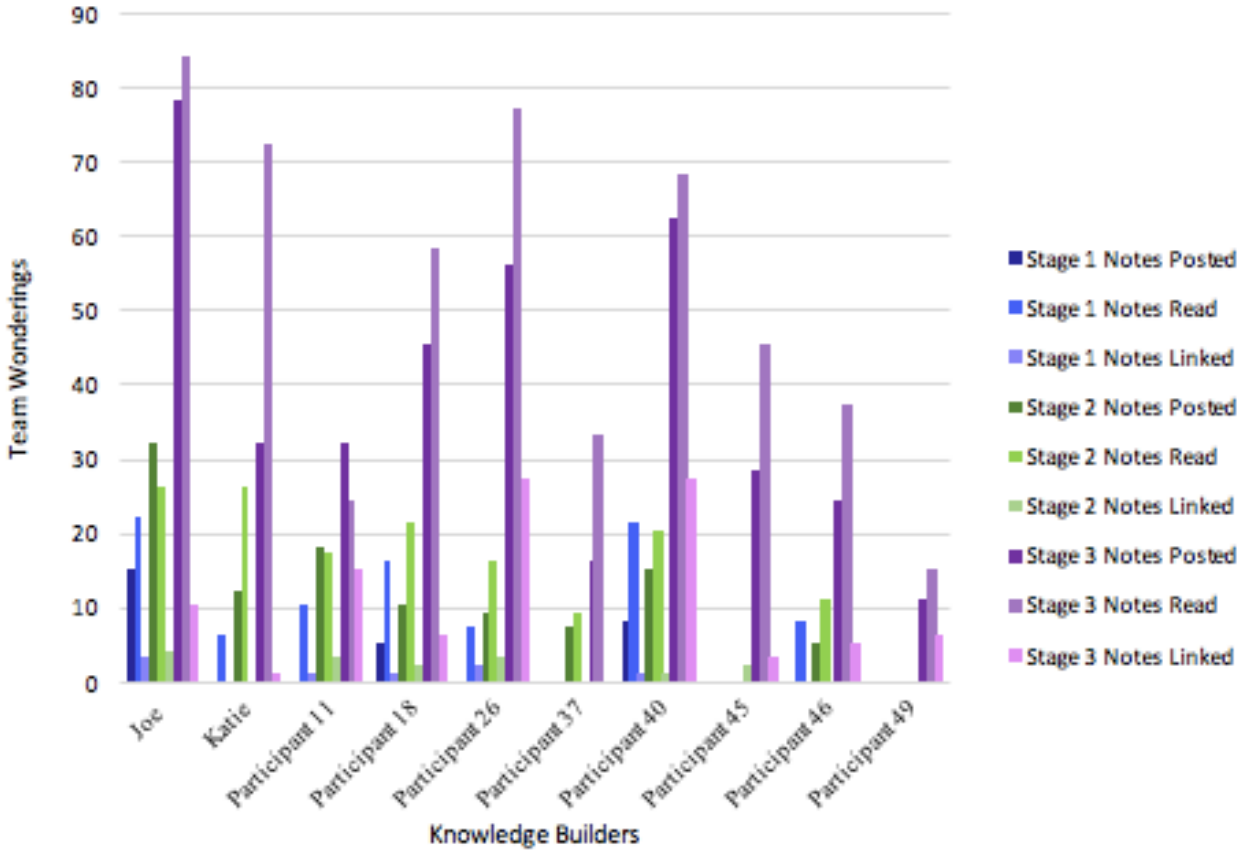

Figure 31. Knowledge Team Idea Build Interactions During Three Stages of Idea Development

The server data extrapolated from the network measured the number of Team Wonderings posted and read by each team member as well as the number of Team Wonderings that were linked and used to create various scaffolded Idea Builds. An analysis of the Team Wonderings Forum illustrates that interactions and increased knowledge contributions occurred during Stage 3 of the Idea Build Development. This was the stage where teachers were collaboratively focused on developing their Moodle assessment tool and had created a series of Google Docs to support ongoing and

sustained idea development. The interaction patterns of the Knowledge Team Builders in Figure 31 demonstrate that the interactions of team members were at the highest density and volume when the group became focused and committed to developing the Moodle tool.

The evolution of this Knowledge Team demonstrates the need for the development of a clear, shared purpose among team members in order for higher-level knowledge building and collaborative inquiry to be sustained. A greater diffusion of information and knowledge was demonstrated by the combining of individual expertise and the teacher's engagement in multiple discussion threads within the Knowledge Team Wonderings Forum. The interaction patterns of team members within the Knowledge Team Wonderings Forums also moved away from teacher-to-teacher discourse patterns to whole group discussions within the Knowledge Team Wonderings Forum, indicating that pervasive idea exploration and shared understanding occurs only when teachers feel that they are tackling a meaningful challenge directly related to their professional practice.

In this Knowledge Team, as well as several other high functioning teams within the network, the emergence of the above three stages of Idea Building led to higher levels of shared knowledge construction. When teachers had a common shared purpose with multiple opportunities to meet online and face-to-face to advance and organize their work, an increase in shared knowledge construction was nurtured and participants became more actively engaged in the network.

Knowledge building. All Idea Builds were analyzed to better understand the level and complexity of knowledge that was created within the network. Key knowledge

building principles were identified from the coding of the Idea Builds and a clearer picture of knowledge sharing began to emerge.

Creating higher-level knowledge artefacts. The development of shared Knowledge Artefacts is supported by sustained mutual interactions between and among multiple Knowledge Builders as they developed and improved various Idea Builds. The development of higher-level Knowledge Artefacts evolved when teachers began to combine their individual knowledge and expertise around one focused idea or area of inquiry.

To further analyze the level of Knowledge Artefacts that were developed and shared within the network, Idea Builds were analyzed using five levels of knowledge construction. A coding scheme was constructed that considered the level of collective responsibility involved in developing the idea, the extent of knowledge building discourse associated with the Idea Build, and evidence of innovation or knowledge advancement. The results of this coding are illustrated in Figure 32 and indicate that to move to higher levels of idea development, multiple Knowledge Builders are required to share their expertise within a team, while focusing on a common culminating idea or artefact.

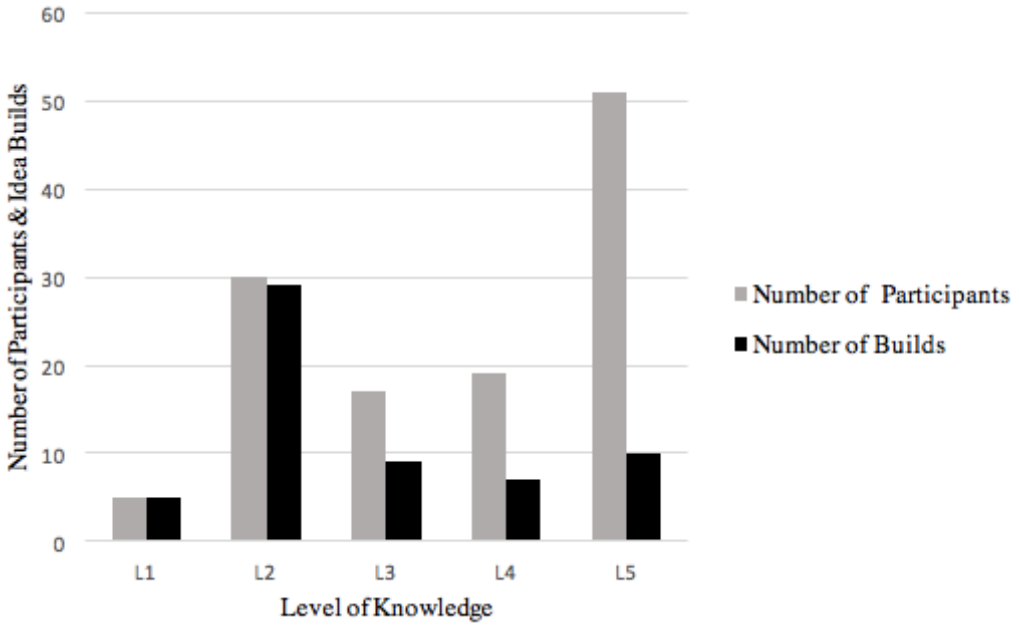

Figure 32. Level of Knowledge Constructed in the Network

Creating and maintaining a core set of Knowledge Builders with a variety of expertise and teaching experiences played an important role in developing and sustaining effective idea exploration. The network made it possible for frequent knowledge interactions to occur in a profession where meeting and developing new ideas is often difficult. The network also provided a team discussion forum and a common space to store team files and resources. This allowed all Knowledge Builders to have equal access to new information and group expertise, and to share artefacts throughout the Idea Building process.

In higher-level Idea Builds, teachers demonstrated joint problem solving and developed a sense of commitment to collaborative inquiry that sustained knowledge creation even though many teachers were geographically distributed throughout the

division. Katie explained how teachers in one Knowledge Team used the Team Wonderings Discussion Forum to keep track of group work:

> We were all in different schools so posting questions or feedback in the Team Wonderings about our Idea Builds was the easiest way to communicate with one another. We knew the posts were connected directly to our work email, so we were all in the loop even if we weren't all in the network.

The knowledge building tools created in the network supported open and flexible communication among team members and this seemed to help teams navigate through computer-mediated communication and build a commitment to the collective knowledge building community. The results from the *Idea Building Participant Questionnaire* reveal that 31 out of 50 participants found that the various features in the digital tool made knowledge accessible during Idea Building.

Teachers' perceptions of the shared knowledge creation process. An examination of the Idea Builds within the network provided a better understanding of the interactions and social structures needed to develop higher-level co-constructed artefacts. Another key area that was examined at the end of the study was individual understandings of the shared knowledge creation process within the network. During the face-to-face interviews, a prioritization card sort was administered to each of the ten interviewees. Participants were provided with a set of index cards, with the nine knowledge building principles and definitions printed on them. Interview participants were then asked to organize the knowledge building principles in a manner they felt best illustrated an effective cycle of shared knowledge creation. The resulting ranking and order of each interviewee is presented in Table 9.

Table 9.

Results of Knowledge Building Principles and Inhibitors Card Sorts.

Participants	KB1: Real Ideas & Authentic Problems	KB2: Improvable Ideas	KB3: Idea Diversity	KB4: Rise Above Ideas	KB5: Epistemic Agency	KB6: Collective Responsibility	KB7: Knowledge Building Discourse	KB8: Constructive use of Authoritative Sources	KB9: Transformative Assessment
1	1	6	3	4	7	5	2	9	8
2	6	3	4	7	9	1	2	5	8
3	6	9	2	4	3	1	8	5	7
4	7	6	2	4	3	1	9	5	8
5	1	6	2	4	3	7	5	9	8
6	7	6	2	4	9	1	3	5	8
7	1	3	2	4	9	7	6	5	8
8	7	6	2	4	4	1	3	9	8
9	7	6	2	5	3	1	9	5	8
10	2	4	7	4	3	1	9	5	8
	7	6	2	4	3	1	9	5	8
Re-Sort	**KB6: Collective Responsibility**	**KB3: Idea Diversity**	**KB5: Epistemic Agency**	**KB4: Rise Above Ideas**	**KB8: Constructive use of Authoritative Sources**	**KB2: Improvable Ideas**	**KB1: Real Ideas & Authentic Problems**	**KB9: Transformative Assessment**	**KB7: Knowledge Building Discourse**

The top coloured strip demonstrates the nine knowledge building principles that were adapted from the work of Scardamalia and Bereiter (2003). The bottom coloured strip presents the re-organizing of the knowledge building principles by the ten interview participants by majority of responses.

During the prioritization tasks, most participants (seven out of ten) moved the Collective Responsibility card to the front of their card sort, indicating that a strong sense of collective responsibility within a knowledge building community was an integral first step to successful shared knowledge creation. Joe commented in his interview that "…without those close professional relationships, I can't see how teachers would ever come together to explore and discuss challenges in their professional practice." All interviewees commented that the best and most effective way to build these professional relationships was through face-to-face contact.

One interesting shift in the knowledge building process for the interviewees was the re-ordering of the Constructive Use of Authoritative Sources. Interview participants felt that other teachers were an important authoritative source within idea exploration and that external academic sources, published programs, and key researchers were also valuable knowledge assets that were necessary in effective collaborative inquiry for teachers. Katie clearly illustrated this concept in her interview: "Other teachers in the network helped me strengthen my teaching practice by introducing me to new programs and resources. Their experience and knowledge helped me survive my first year of teaching."

The final key shift in the card sort was the placement of the knowledge building discourse card to the end of the knowledge creation cycle. Eight out of ten interview participants felt knowledge building discourse occurred more often after completed Knowledge Artefacts were shared. The retrieval of the shared Knowledge Artefacts and the feedback teachers received regarding usefulness or revisions was the most common basis for this kind of discourse. Providing selected teacher participants an opportunity to articulate their personal experience with shared knowledge creation within the network emphasized the features and tools that effectively supported knowledge building and provided suggested revisions that need to be considered with regards to the conceptual framework.

Knowledge building barriers. Central to the notion of shared knowledge creation and idea building is the ability of individuals to continually contribute and assess shared knowledge in the network. A knowledge building network is only effective if there is active participation of all network members through the sharing and exploring of

various ideas. While there were examples of highly effective knowledge sharing and idea development in the network, knowledge building barriers were still present that prevented some teachers from participating in collaborative knowledge building.

Professional barriers to knowledge building. Of the 50 participants within the research study, 11 did not join a Knowledge Team or engage in shared Idea Building. Most of these participants (seven out of 11) were master and expert teachers.

Figure 33 provides a graphical presentation of Maggie's participation in the network across all four phases of knowledge creation. Maggie's profile is typical of the level of network engagement demonstrated by most of the master and expert teachers.

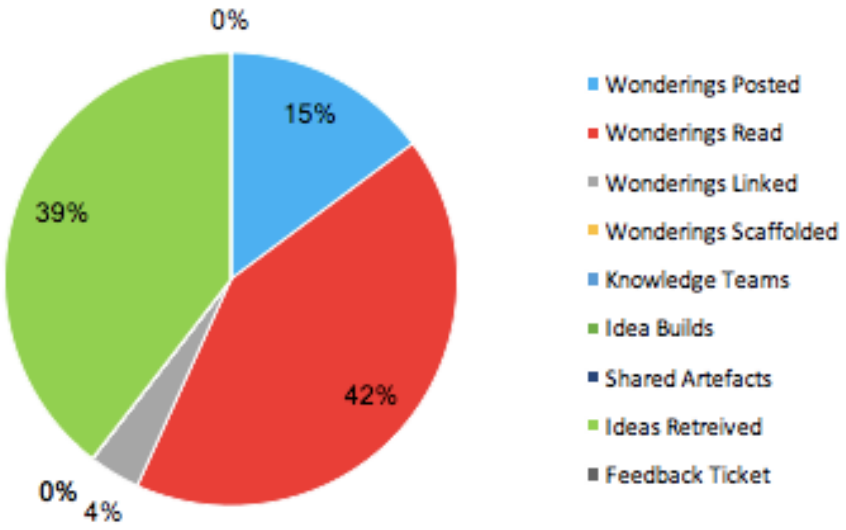

Figure 33. Detailed network participation across four phases of knowledge creation (Maggie)

At first it seemed that Maggie was not interested in sharing her expertise with other teachers in the network even though there were a variety of Idea Builds and

Knowledge Teams available to her. However, during her interview, Maggie clarified that it was her perceptions of professional learning and teaching that impacted her success within the network:

> I am used to attending larger workshops or conferences and getting my professional learning from these avenues. I just see teaching as a personal practice where you acquire new ideas and learning and then you integrate that into your practice. I liked being able to gather resources from the network, but I always tweaked these to suit my teaching style. I think good teaching has more to do with individual creativity than collaboration, so I just didn't see the value in creating something with other teachers that I was going to personalize in the end.

As Maggie illustrates, teachers often have a personal connection to their professional practice and may view the teaching profession as an individual endeavour, where knowledge and expertise is built through isolated professional learning opportunities. When knowledge is viewed as an individual asset, individuals have control over how much knowledge they want to share. According to Jarvenpaa, Shaw, and Staples (2004) knowledge that is perceived to be owned by an individual is less likely to be openly shared; instead it becomes associated with other intangible returns such as status and reputation.

However, in a practice-based profession such as teaching, the systematic learning and sharing of knowledge in teacher practice is critical to advancing the profession. By creating an environment where teachers work together as a collective community, knowledge becomes created and embedded within the community and is no longer a personal investment. In order for effective knowledge sharing to occur, teachers need to

see value in engaging in collaborative knowledge building and collaborative structures that improve individual practice, while also developing the profession.

Evaluation apprehension. Higher-level Idea Builds demonstrated knowledge reciprocity where teachers created a balance between their individual knowledge contributions in the form of artefacts shared in the network and the retrieval of shared Idea Builds. A perception of *sharing fairness* seemed to develop where teachers attempted to find a balance between the resources they developed in the network and what they retrieved. However, an important barrier to Idea Building and knowledge sharing was identified through an analysis of server log data and the interview responses of novice and apprentice teacher. Reviewing the number of Idea Builds that were created and shared by novice and apprentice teachers indicated that both groups were less likely to share their individual Knowledge Artefacts with the network community (see Table 10).

Table 10.

Number of Idea Builds Created and Shared by Teacher Expertise

Teacher expertise level	Number of Idea Builds created	Number of Idea Builds shared
Novice	25	5
Apprentice	17	11
Specialist	48	15
Master	29	7
Expert	10	6

Interview responses from two novice teachers revealed a fear of possible criticism of the artefacts they developed from other more experienced teachers. Katie indicated that she felt most comfortable when she was sharing a co-constructed Knowledge Artefact rather than something she developed by herself. She said, "I was fine to work alongside a group of teachers and share items, but when it came to sharing my own resources, I was hesitant. I just wasn't sure anyone would see them as valuable." One way to overcome the barrier of evaluation apprehension is to strengthen the relationships within the knowledge building community. This can be done through posted Wonderings that encourage and praise new teacher knowledge contributions within the network and through face-to-face interactions.

One of the main conclusions of this study is that mechanisms that develop and support higher levels of community trust are essential for effective knowledge creation. Participants indicated in the online questionnaires and interview responses that developing trust and building relationships with other teachers was integral to the success of their knowledge work within the network. More than half of the participants in the questionnaire data (31 out of 50) strongly agreed with the statement that trust and relationships needed to be supported for teachers to share and develop knowledge together.

Most participants felt that the best way to achieve higher levels of trust was through face-to-face interactions. Bill indicated that meeting with his team members at division level PLCs was an important first step to developing a more cohesive team: "Before, we were all just posts and comments. When I could put a face to a name I definitely had a better connection online with my team." Offline interactions were found

to strengthen the community bonds and relationships of shared Knowledge Builders. While an asynchronous network environment supported the technical aspects of shared knowledge building, limited tools were offered in the network to support the development of social relationships and trust.

Phase IV: Knowledge Artefact Assessment and Retrieval

The final phase of the knowledge creation conceptual framework focused on the assessment and retrieval of shared Knowledge Artefacts. Server log data of artefacts retrieved by participants from the network were compiled. Also, content analysis of the Artefact Assessment Tickets attached to various knowledge objects was conducted to examine the kinds of transformative assessment required to advance and develop shared knowledge.

Interactions. In Phase IV of the conceptual model, we see the highest level of participant engagement with regards to artefact retrieval within the network, but we also see the lowest level of interaction with regards to artefact assessment. For most teachers, initial engagement and participation in the network started by searching and retrieving shared knowledge artefacts. The network was designed to provide easy access to teacher resources by organizing knowledge content by grade, subject area, and curricular outcome. For some teachers, the purpose of the network became more of a database of resources rather than a knowledge building network. One pattern that was identified through an analysis of individual server log data (See Table 11) is that master teachers above all other teachers used the network mainly for artefact retrieval.

Table 11.

Number of Knowledge Artefacts Retrieved by Level of Teacher Expertise

Teacher expertise level	Number of teachers	Number of artefacts retrieved (*average number of artefacts per teacher*)
Novice	9	118 (13.1)
Apprentice	11	107 (26.6)
Specialist	16	118 (7.4)
Master	9	239 (26.6)
Expert	5	24 (4.8)

In the Idea Build questionnaire data, 17 out of the 50 participants used the system as a tool to acquire new resources and assessments. In the questionnaire, these 17 participants indicated that they viewed the network not as a space to develop new knowledge, but as a place to gather knowledge content. Maggie indicated that she felt "the network was a place to access best practices and learn about new pedagogical practices." The discourse patterns of these 17 participants also indicated that their main interactions with other teachers occurred within the Wonderings Discussion Forum to connect with other teachers who had shared specific Knowledge Artefacts.

The inability of some network members to engage in shared Idea Building suggests that the purpose of the knowledge building network was often misaligned between different network members. Some teachers viewed the network as a place to generate and create new knowledge together, while others saw it as a digital database for

gathering and retrieving existing content. Earlier face-to-face interactions and clearly communicated norms regarding knowledge building and sharing might have engaged more teachers to join Knowledge Teams and participate in knowledge building, but these messages needed to come at an organizational level so that supportive structures, such as face-to-face meetings and divisional goals regarding collaborative knowledge sharing, could be developed throughout the district.

Knowledge Building. A critical factor of sustained knowledge creation is the willingness of Knowledge Builders to actively participate in the improvement and advancement of ideas through embedded transformative assessment. One of the goals of this knowledge building network was to provide teachers with opportunities to give feedback on shared Knowledge Artefacts that would assist in the further development and innovation of teacher professional practice.

In a knowledge building network, individual members develop their own professional knowledge, not just by sharing and retrieving the shared artefacts within the network, but also by improving and advancing shared ideas. An effective knowledge building network relies on the improvement of shared artefacts through sustained interactions where teachers move beyond the accumulation of individual knowledge artefacts and resources and shift to improving and developing the collective knowledge of the entire network community. To support ongoing idea improvement, an Artefact Assessment Ticket was developed that allowed teachers to assess shared Knowledge Artefacts and provide specific, ongoing feedback.

To further examine the kinds of transformative assessment and feedback that was generated by teachers in the network, Artefact Assessment Tickets were coded using a

series of Knowledge Artefact Assessment Principles. These assessment principles combined both the social and individual aspects of knowledge assessment that contribute to the advancement of shared knowledge (see Table 4).

Of the 73 ideas shared by teachers within the network, only 29 received feedback tickets from other network members. Data analysis of the feedback tickets indicated that most teachers provided feedback that focused on working together at the cutting edges of ideas and professional challenges. Most of these feedback tickets identified knowledge gaps or inconsistences in the artefacts that were shared within the network. Often these tickets sought to engage other members in a discussion about a Knowledge Artefact (See Figure 34).

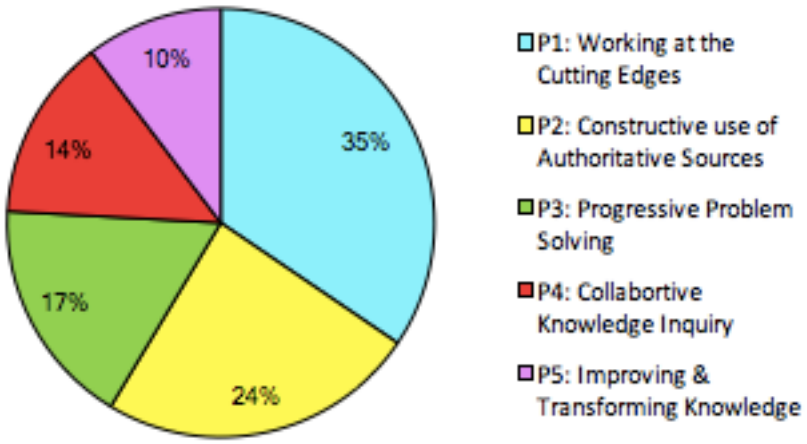

Figure 34. Breakdown of Feedback Tickets by Knowledge Artefact Assessment Principles

Another key principle that teachers incorporated into their feedback tickets was the Constructive Use of Authoritative Sources. Most of these tickets provided an alternative method of teaching or assessment and included personal anecdotes or advice that improved a shared Knowledge Artefact. An example of this higher level of transformative assessment is illustrated in the following feedback ticket added by a teacher on a Knowledge Artefact that focused on syllabication (See Figure 35).

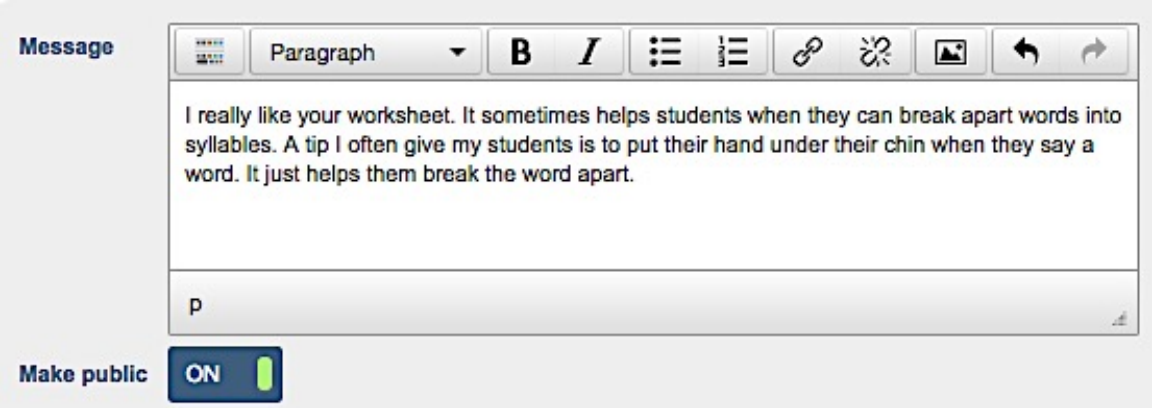

Figure 35. Sample of Teacher Feedback Ticket Attached to a Shared Knowledge Artefact

The inclusion of these professional tips and strategies improved the shared artefacts, but it also exemplifies how knowledge and expertise is easily diffused within a networked environment because all network members have access to the feedback tickets associated with each individual shared artefact.

Knowledge barriers. Ongoing assessment of Knowledge Artefacts is an integral component of knowledge advancement. Embedded transformative assessment within a knowledge building community is used to identify problems or issues with the ideas that were co-constructed, and provides opportunities for shared ideas to be further developed and improved. Through an analysis of the responses to the *Idea Building Participant*

Questionnaire, I found that application of transformative assessment within the network was lacking. Only 17 of 33 participants agreed with the statement that knowledge building involved assessing and improving shared artefacts in the network, indicating that the shift from a focus on knowledge creation to deeper reflection and group evaluation was a struggle for some of the network members. Even when a feedback ticket was introduced as a transformative assessment feature, the knowledge building community rarely engaged in providing feedback to one another on shared artefacts.

It was interesting to see that most teachers felt comfortable retrieving shared artefacts from other network members, but providing feedback was not well supported. While the intention of the feedback ticket was to assist teachers in improving and developing shared knowledge, many teachers felt awkward assessing the work of their colleagues. Joe, who was well connected in the network, commented in his interview that the Artefact Assessment Ticket was not a feature he utilized often: "It just didn't seem right to assess the work of other teachers. Who am I to judge the effectiveness of their work and resources?"

While the intent of the feedback ticket was to support transformative assessment that would develop and advance the collective knowledge within the network, most teachers saw it as a personal assessment of teachers' individual professional practice. This blurring of the purpose behind embedded transformative assessment with regards to effective knowledge building led to a decrease in the level of knowledge developed in the network. Rather than use the Artefact Assessment Ticket, most teachers chose to provide feedback within their Knowledge Team Discussion Forums, perhaps because there was a

greater level of relational trust and teachers felt it was a safe place within which to have these conversations.

Transformative assessment of co-constructed knowledge helps to continually advance and improve the ideas of a community. Findings from this study indicate that a feedback ticketing system did not adequately allow teachers to improve and advance knowledge in the network because the purpose of the ticket was viewed as evaluative rather than transformative. Also, the tickets focused more on the end-point of a completed Knowledge Artefact rather than embracing the concept of embedding assessment throughout the knowledge creation process. A different assessment feature would therefore need to be created to support collective aspects of embedded transformative assessment in a networked environment.

Chapter Summary

This chapter presented findings from the case study specific to the four phases of knowledge creation developed in the conceptual framework. Analysis of the data throughout all four phases focused on three key themes: interactions, knowledge building, and knowledge barriers. The analysis of the data of the study determined that for a teacher professional knowledge building network to be successful, a clear purpose needs to be established for the use of the network across an educational system. Also, interactions among network members indicated that teachers need ongoing and multiple face-to-face meetings to strengthen relationships and establish trust for effective knowledge building to be sustained. Finally, further leadership and organizational supports are needed to develop collaborative structures within school divisions to nurture and support shared knowledge creation among teachers. These conclusions and their

implications for educational institutions are discussed in greater detail in Chapter 6, along with additional recommendations. The contributions of this study and its potential limitations are also discussed in Chapter 6, and the chapter concludes with a discussion of future directions for this research.

CHAPTER SIX: DISCUSSION

The main research question posed for this case study was: How could the development of professional knowledge building network influence teacher-shared knowledge creation? The four sub-questions were:

a) How do teachers build and share knowledge in a networked environment?

b) How do the interactions among teachers impact shared knowledge creation?

c) What knowledge building barriers impact a networked environment?

d) What types of features are required to create an effective knowledge building network?

In this chapter the discussion will link the findings from the case study to existing research and answer the research question for this case study. The first section of the chapter presents revisions to the conceptual framework with an accompanying synthesis of the literature, knowledge creation approaches, and research findings to illustrate how teacher-shared knowledge creation is developed within the network tool. The second section explores the connections between teachers as they build and share knowledge in a networked environment. The third section presents common themes on Knowledge Building Inhibitors identified in the study. The final section discusses the role of personalization with regards to specific features required in an effective knowledge building network, as well as overall network design. The chapter concludes with an overall discussion of the findings and a brief chapter summary.

Revisions to the Conceptual Framework

Shared knowledge creation among teachers can lead to more effective instructional practices and improved student learning. However, teachers often function

in complex environments where the responsibilities of the job, time, and geographical distance disrupt the flow of collaborative Idea Building and prevent sustained shared knowledge building. In response to these challenges, this study developed a teacher professional knowledge building network and analyzed its effectiveness with regards to teacher-shared knowledge creation.

Throughout this case study, knowledge building was viewed as an iterative process where the professional experiences, expertise, and specialized skills of individual teachers came together through a variety of interactions to collaboratively explore and develop shared ideas. Initially, a conceptual framework was developed that included four inter-related phases of knowledge creation: 1). Wonderings, 2). Knowledge Team Development, 3) Idea Building, and 4). Artefact Analysis and Retrieval. The initial framework supported the premise that knowledge creation is a cyclical process that involves a step-wise progression of four phases of knowledge creation that support the socialization, externalization, combination, and internalization of tacit and explicit knowledge as outlined in the knowledge spiral (Nonaka & Takeuchi, 1995).

The findings from the study revealed, however, that while knowledge creation does involve elements and characteristics found within the each of the four phases of the conceptual framework, individual Knowledge Builders in a network environment do not follow a cycle of progressive phases during knowledge creation, but rather an iterative process that has multiple entry points and interactions occurring between and among other Knowledge Builders.

The key phases embedded within the conceptual framework, I believe, are still the foundational building blocks of knowledge creation, but revisions were made to both the

four phases of the framework and the role of the knowledge building spiral. These revisions illustrate the stages of knowledge creation experienced by teachers during the case study and inform the various design elements required in the development of an effective professional knowledge building network

How do teachers build and share knowledge in a networked environment?

The original conceptual model presented four phases of knowledge creation integrated with the four modes of knowledge conversion (socialization, externalization, combination and internalization) in the knowledge spiral. The first key revision made to the conceptual framework was a distinction between the process of knowledge building experienced by individual teachers and the different network elements needed to support shared knowledge creation throughout the network. The data from the case study revealed that the knowledge building experiences of individual teachers is well represented by the components in the knowledge spiral; however, the transformation of tacit knowledge to explicit knowledge is an ongoing process that can occur during all the phases represented in the conceptual model and is not isolated to specific phases (see Figure 36).

This coincides with the assertion by Nonaka and Takeuchi (1995) that knowledge is context specific in terms of time, space, and relationships. Therefore, the process of building and sharing knowledge is not effectively represented by isolated phases in a framework. Instead, the phases represent the key components needed in the design of a knowledge building network to support the various contexts and processes involved in successful knowledge creation. The following section outlines the revisions made to the conceptual model and reflects findings from the research.

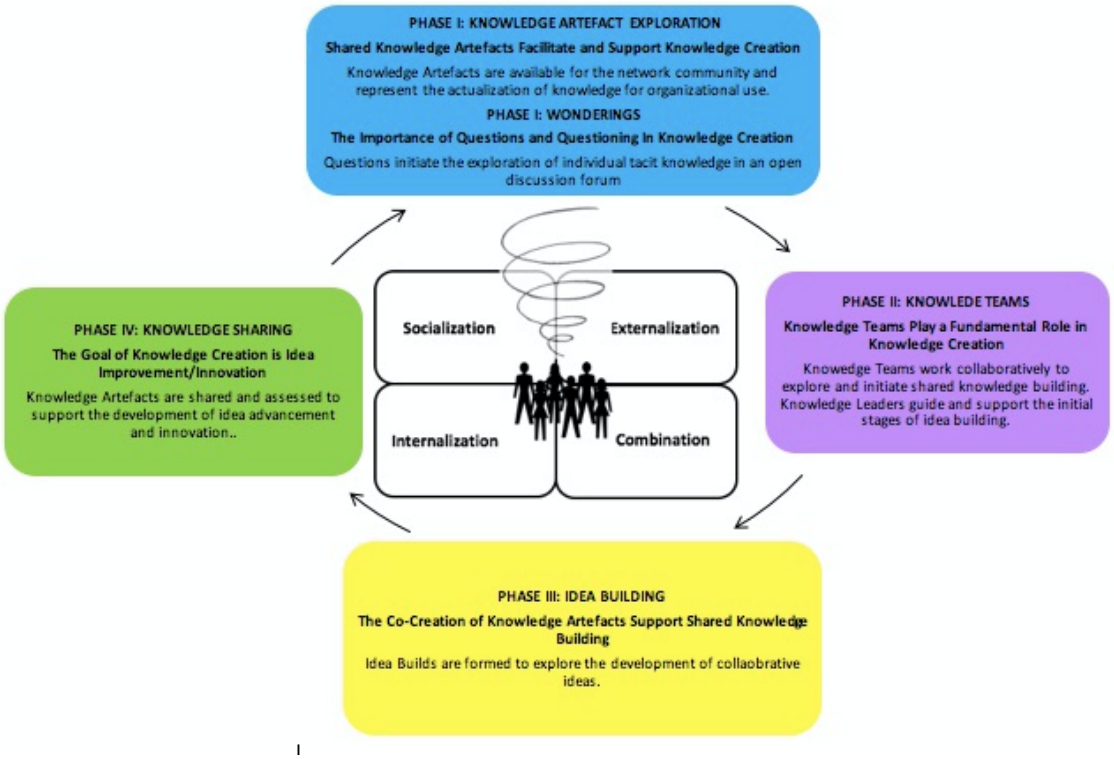

Figure 36. Revised Conceptual Framework for the Creation of Shared Professional Knowledge

Knowledge Spiral: Shared knowledge building experiences. Nonaka and Takeuchi (1995) defined tacit knowledge as the specialized knowledge that individuals acquire though their professional practice. For teachers, tacit knowledge is personal, practical, and context specific. It is often deeply embedded in their teacher professional practice and difficult to share with others, yet it includes the most valuable knowledge needed to innovate and advance the profession.

At the beginning of the knowledge spiral (Nonaka & Takeuchi, 1995), the process of socialization is used to share experiences and create common mental modes between teachers as they begin to share and build knowledge. Jantsch (1980) suggested that

socialization often requires individuals to reach out beyond the boundaries of their own existence and across social barriers to share what are often personal experiences. As they moved through the knowledge spiral in the network, teachers often externalized their tacit knowledge by articulating their experiences, thus making knowledge more explicit so that it could become the foundational basis for new ideas that could be collaboratively built and scaffolded together in Knowledge Teams.

This explicit knowledge was then connected, developed, and revised to form more complex knowledge during the combination process. Finally, this new combined knowledge was shared throughout the network, then internalized by other teachers and converted back to tacit knowledge that was used in new practical situations. Often this new knowledge was shared with other teachers through Knowledge Artefacts and triggered innovations within teacher professional practice.

These processes within the knowledge spiral were originally thought to occur during the separate phases outlined in the conceptual framework, but on closer examination of the research findings, the conversion of tacit to explicit knowledge occurred throughout all phases of the knowledge creation framework and cannot easily be separated into sequential phases or steps. This revision to the conceptual framework is illustrated by the internal knowledge spiral now added in the centre of the framework (see Figure 36), implying an ongoing process that occurs throughout the various areas of the network.

An important consideration for this research is understanding that the four modes of knowledge conversion were not cyclical in nature, but rather a spiral that became larger and amplified in the network by increasing interactions between teachers as they

shared tacit and explicit knowledge. Using the image of a spiral also demonstrates that knowledge creation is not bound by the network environment; it instead lives in the experiences and interactions of teachers and moves beyond organizational structures, professional learning communities, and even the network itself.

Phase I: Knowledge Artefact exploration and Wonderings. The digital tool created for this study included a Wonderings Discussion Forum that was designed to support the first phase of knowledge creation and initiate the development of knowledge building discourse. The discussion forum was created to provide opportunities for teachers to begin sharing their tacit knowledge through pervasive idea exploration.

The research findings indicated that not all teachers used inquiry and the discussion forum as their main method for entering the knowledge creation process. Instead, some experienced teachers entered the network to retrieve shared Knowledge Artefacts. These knowledge assets often became the main initiator of shared knowledge building. An analysis of network behaviour revealed that the earlier stages of shared knowledge creation for experienced teachers often transcended initial inquiry and discourse discussions that focused on professional practice, and instead involved the retrieval of shared knowledge artefacts, then reconceptualising how these objects could advance personal professional practice.

Scardamalia (2002) discussed the need for successful knowledge building communities to exhibit deep embedding of ideas, that is, "…the embedding of ideas in larger conceptual structures and the embedding of ideas in the practices of the knowledge building community" (p.7). For a teacher professional knowledge building network to be successful, multiple entry points that can be accessed by teachers are recommended

because teachers initiate idea improvement in a variety of ways based on teacher expertise. For example, providing novice and apprentice teachers with a general discussion forum where they can post their initial ideas and Wonderings was an essential component of their knowledge building development. Master and expert teachers required a database of shared artefacts that they could use as a starting point to further develop shared ideas. Providing multiple entry points into the knowledge building process provides opportunities for sustained idea improvement because it supports the diverse knowledge building triggers teachers need when initiating shared knowledge creation. Phase One of the conceptual framework has been revised to reflect the exploration of authentic problems through individual Wonderings and the synthesizing of shared knowledge artefacts through an Artefact Retrieval system as the main drivers for initiating shared knowledge creation.

Phase II: Knowledge Teams. Effective Knowledge Teams in the network shifted away from the traditional concept of a community of practice—as a bounded entity comprised of teachers coming together to acquire knowledge related to specific tasks outlined by the community (Lave & Wegner, 1991)—and moved to a more flexible self-organizing community. The membership within the school district professional learning communities were often organized by specific grades or subjects and tasks that were often pre-determined at the beginning of the school year. In the knowledge building network, the members of Knowledge Teams focused less on tasks and more on idea exploration.

Originally, the literature reviewed for this research indicated that as teachers moved into network teams they would create critical colleagueship (Lord, 1994) where

they engaged in critical conversations about their teaching practice and focused on professional improvement. However, during the case study, effective Knowledge Team members engaged more in experiential discourse where they learned how to share their experiences and explore the essence of an idea rather than critically assess individual teaching practices. Nonaka and Toyama (2003) referred to this existential place where participants share their contexts and new meanings though experiences and interactions as *ba*. Members of a community of practice are often restricted by organizational structures such as grade or subject groupings, meeting times, and the focus of the community work. In contrast, participants of *ba* move with knowledge and organize around ideas. Groups emerge and disappear according to the purpose and need of the work and people interact with one another based on the meaning they create together.

Knowledge Teams that were most effective in the network demonstrated specific characteristics of *ba*, such as shaping and reshaping their groups as the need and focus of the knowledge work changed. Team members also experienced multiple viewpoints as an insider and outsider at the same time, so they could understand all the edges of an idea. Nonaka and Toyama (2003) conceptualized that good *ba* "enables actors to detach themselves from day-to-day routines, externalize their personal knowledge and to view a given phenomenon from various points simultaneously" (p. 8). The ability to share multiple perspectives helped depersonalize instructional practices in Knowledge Teams so that teachers could focus on the development of a shared idea as a group rather than the improvement of individual practice. Developing and supporting a sense of *ba* in Knowledge Teams was an important component of successful shared knowledge creation.

Leadership within Knowledge Teams is also another important consideration for supporting an effective knowledge building network. During the case study, effective Knowledge Teams often had one member that adopted the role of Knowledge Leader. These members were often the main conduits of knowledge and information flow within the team and demonstrated a commitment to collective and collaborative processes required of effective networking leaders (Hopkins & Jackson, 2003). These teacher leaders also supported the introduction and immersion of new team members and were key organizers of team communication and cross-pollination of ideas and knowledge in the network.

Sharing knowledge and ideas from other teams often enhanced team understandings and provided opportunities for ideas and knowledge work to be scaffolded to higher levels. Many of these Knowledge Leaders became expert motivators of knowledge work and, as teams developed in the network, the presence of Knowledge Leaders began to emerge to help organize and spread ideas with other team members. The key characteristics that were exhibited by these Knowledge Leaders during the case study were information brokers and organizers of team knowledge, facilitators of cross-team knowledge sharing, and leaders during offline interactions.

The positioning of Knowledge Leaders within various teams provided opportunities to build strong cooperative relationships with their colleagues; they also served as important catalysts to support sharing of knowledge artefacts in the network. An important distinction made during the study was that the role of a Knowledge Leader was not created within the hierarchy of the network through specific network permissions or higher access points. Rather, the role evolved through the knowledge creation process.

Knowledge Leaders emerged as ideas and collaborative inquiry developed in the network; they demonstrated a laser-like focus on knowledge advancement by ensuring that collective knowledge building was the core work of the Knowledge Team and that knowledge was diffused throughout the network.

Phase III: Idea building. A key transformation that needs to occur when considering teacher professional development is a shift from activity-centred professional learning to idea-centred collaborative learning (Scardamalia & Bereiter, 2003). Professional knowledge building networks place ideas at the forefront of community work and they become the fundamental building blocks of shared knowledge creation. As teachers joined the network during the case study, they needed to learn how to explore, adapt, and combine their multiple expertise rather than focusing only on individual needs.

To reach this higher level of shared knowledge creation, the literature suggested that teachers needed to learn how to combine their individual intelligences and develop collective wisdom (Lévy, 2009). The research suggested that effective knowledge networks needed to provide opportunities for teachers to engage in complex problems that required multiple intelligences, experiences, and expertise.

The findings from this research indicated that teachers moved to higher levels of collective wisdom through three stages of idea development. At the first stage of independent knowledge construction, teachers entered the network as independent Knowledge Builders. They would retrieve shared artefacts and sometimes share individual resources, but there was little connection or interaction with other network members. The trigger that seemed to move teachers into the second stage of idea development, known as collaborative idea exploration, was the introduction of a

compelling professional challenge. When teachers found a common purpose to engage in the network, their exploration of ideas often required shared expertise and multiple intelligences. As teachers moved to the highest level of Idea Building, which focused on co-constructed knowledge, the collective wisdom of the group focused on shared problem solving and idea improvement (see Figure 37).

Figure 33. Idea Build Development

Even though some Knowledge Teams reached the highest level of idea development, the network was not effective in providing opportunities for teachers to engage in complex problem solving. At present, the structure of the network focused more on the building of shared artefacts rather than the processes and tools needed to support the development of collective wisdom and shared idea exploration. While the tool provided an easy organizational structure for teachers to build and retrieve artefacts, it did little to support the initiation of deep idea investigation.

Creating a space in the network where professional challenges can be discussed could build the narrative of inquiry (Ball & Cohen, 2000) originally referred to in the literature review, where there is a shift from professional politeness to deeper knowledge building discourse focused on the critique and improvement of teacher practice. The Wonderings Discussion Forum that is currently in the tool was not robust enough to

support the complex interactions and interconnectedness teachers require to effectively develop shared ideas around complex professional problems. Developing a responsive and personalized space where teachers could openly share pedagogical challenges and combine their expertise may increase the level of idea exploration in the network and nurture the development of teacher collective wisdom.

Phase IV: Knowledge sharing. The findings of the study revealed that teachers used multiple entry points into the network. Originally, the conceptual framework suggested that teachers would use an inquiry process to connect with each other and self-organize into Knowledge Teams. Indeed, Scardamalia and Bereiter (1994) proposed that knowledge creation requires a shift in focus from knowledge organized by topics and categories to a focus on authentic problems that are collaboratively explored by groups of teachers. During the case study, however, experienced teachers often entered the network in search of shared Knowledge Artefacts. It was these artefacts that became the key trigger for further conversations and, sometimes, idea development.

For those teachers who have established themselves through professional experience and expertise, knowledge building was viewed as an evolutionary process and shared artefacts provided the initial starting point. In this case, the advancement of current knowledge was the starting point for many teachers and often the rationale to enter the network. For example, experienced teachers in the network indicated that a key reason for participating in knowledge building was to develop new knowledge or skills that they currently did not have in their teaching practice. This was often initiated because they were asked to teach a new subject or grade level and were lacking the skills and resources to support high levels of learning for their students.

The initial conceptual framework positioned knowledge creation as the product of collaborative inquiry, but findings from the case study demonstrated that the improvement and advancement of current knowledge can also be used to initiate the knowledge building process. The research findings indicated that teachers needed both shared knowledge artefacts and a platform that could support the rigorous examination of current teacher professional practice. Accessing the network, either by an inquiry question concerning a current teacher professional challenge or through the retrieval of a shared artefact that indicated a gap or need in current teacher practice, would better meet the knowledge building needs of all teachers.

The final revision to the conceptual model was moving Artefact Retrieval from Phase IV to Phase I of the conceptual framework. This reflects the concept that, for teachers, inquiry around professional challenges as well as teacher shared artefacts can activate the knowledge creation process.

Breaking Down the Barriers to Knowledge Building in a Networked Environment

This case study focused on the development of a network tool to effectively support teacher-shared knowledge creation. In addition to learning about effective knowledge building, the findings from the research also identified inhibitors that impacted the effectiveness of the network.

The core purpose of the network was for teachers to co-construct knowledge in order to continually improve their professional practice. However, teachers in the case study were not accustomed to building knowledge together because their district professional learning opportunities often focused on the development of personal and individual skills rather than the collective improvement of the profession. During the case

study, novice and apprentice teachers expressed hesitation with regards to knowledge sharing because they were uncomfortable with their level of expertise or feared criticism from their colleagues. Conversely, some experienced teachers were less likely to share and build knowledge with others because they felt a sense of ownership with regards to the knowledge they had acquired over the years and felt it directly connected to their status as a master or expert teacher. To overcome these inhibitors, teachers in the network needed opportunities to build deeper social ties and relationships with one another.

A common motivator for teachers to share in the network was the desire to help a colleague who was known to them on a personal or professional level. The network did not provide effective relationship building tools that allowed teachers to form these close connections with one another, however, and so knowledge reciprocity was often at a minimum. Chiu, Hsu, and Wang (2006) suggested that the desire to be a part of a community and to contribute to shared knowledge is an important factor in an individual's decision to make contributions to a network. Therefore, creating opportunities through offline interactions, or embedding online chat and video-conferencing tools in the network, could help support the development of closer collegial relationships.

Another important finding from this study is the role that trust plays in successful shared knowledge creation. Participants in the case study commented, in both questionnaire and interview data, that once they knew and trusted other network members they were more willing to share and collaboratively build knowledge. Furthermore, they indicated that until they were acquainted with the other teachers in the network they were

often unsure of the validity and reliability of the artefacts that were being developed and shared.

An important consideration for the development of an effective knowledge building network is to create structures and opportunities for teachers to build knowledge-based trust. Initially, the literature reviewed for this study focused on the development of relational trust between teachers as they engaged in shared knowledge building. However, responses from the participants in the research study indicated that for relational trust to develop, they needed ongoing connections and discourse with other network members.

Tschannen-Moran and Hoy (2001) found that knowledge-based trust emerges based on reoccurring social interactions between individuals and takes root when individuals can predict what to expect from others in specific situations. One of the most effective ways to increase knowledge-based trust that emerged from this case study was providing opportunities for teachers to meet offline. Multiple face-to-face interactions helped develop a foundation of trust and provided opportunities for team members to set norms and standards for sharing knowledge. However, the development of video-conferencing tools in the network and an online chat box would also increase interactions and connectedness between teachers that could further support the development of knowledge-based trust.

Personalization of the Knowledge Creation Process

Knowledge networks have the capability to distribute teacher expertise and promote ongoing development of teacher professional practice. However, the power of knowledge networks does not reside in its technological platforms and databases that

store various resources and information; instead, the power of knowledge networks lies in the various ways individuals harness and leverage their experiences and expertise to advance and support continuous idea improvement.

The essential characteristic of a successful knowledge building network is its ability to connect people in a meaningful way that encourages shared understanding, not just resource allocation. An individual's desire to use and continue using a knowledge network is directly tied to its ability to create a personalized environment with both content and context. According to Tiwana and Bush (2005), personalization in knowledge networks involves two forms: 1.) context personalization, which refers to customizations within the digital environment to support personal identity verification and personal profiling, and 2.) content personalization, which includes the addition of high-powered filters or search engines that allows network members to easily narrow and personalize content found within the network.

During the initial development of the digital tool, a great deal of time and attention was directed towards content personalization. A database was developed within the tool that organized information and resources by grade level, subject, and curricular outcomes. A high-powered search engine called *Elastic Search* was also developed to improve the content personalization of the network tool. However, Tiwana and Bush (2005) indicated that in many knowledge networks a paradoxical effect of personalization often occurs where content personalization does not invoke a higher level of engagement and knowledge sharing in the network. Instead, networks need to develop and nurture context personalization to support sustained knowledge creation. Accordingly, at the end of the pilot study, the addition of a *Knowledge Builder Profile Page* and *Knowledge*

Builder Status Page were added to provide opportunities for users to personally connect with one another in the network. While these features added to the context personalization available in the network, participants still expressed the need to have real and meaningful connections with other Knowledge Builders in the form of video-conferencing tools and offline interactions.

Another important design element required in knowledge building networks is periodic formative feedback to continuously improve knowledge building tools and respond to ongoing Knowledge Builder needs. Due to the iterative nature of shared knowledge creation, knowledge building networks need to mirror the same pervasive idea improvement and advancement that they support. Providing network members opportunities to contribute to the ongoing development of the tool not only supports a culture of collaboration in the network, but also ensures that personalization is continuously supported.

Chapter Summary

This chapter presented a discussion of the research findings and addressed the research questions that were initially proposed at the beginning of the study. The revisions to the *Conceptual Framework for the Creation of Shared Professional Knowledge* emerged from a synthesis of the literature and data from the case study. A detailed discussion was provided concerning the four phases of the conceptual framework as well as the various revisions and modifications.

The next section of the chapter provided a discussion of the Knowledge Building Inhibitors that were identified in the case study, as well as a discussion of the kinds of

features and tools needed in a knowledge building network to support sustained, successful teacher professional knowledge building.

The final chapter provides an overview of the case study and presents reflections on the research process. Implications drawn from the research findings and recommendations for future research are also discussed. A final reflection is provided, outlining the value and originality of this research.

CHAPTER SEVEN: CONCLUSIONS AND RECOMMENDATIONS

A case study methodology was used to explore how the development of an online knowledge building network could influence teacher-shared knowledge creation. The research began with a six-month pilot study to assess the effectiveness of a networking tool designed specifically for this project.

During the pilot study, several Knowledge Building Inhibitors were identified by participant teachers. These knowledge inhibitors negatively impacted the ability of teachers to successfully build and share knowledge in the network. Accordingly, modifications and enhancements were made to the digital tool in response to these inhibitors.

At the completion of the case study, server log data from the digital tool as well as questionnaire and interview response data were analyzed to better understand the kinds of interactions and knowledge building behaviours demonstrated by teacher participants in the network. This research also identified the important role of relational trust, distributed leadership, and network personalization for successful teacher knowledge building. This final chapter provides a reflection on the research process employed during the case study, as well as an overview of specific challenges that were encountered. The dissertation closes with final reflections regarding the value and originality of this research.

Overview of Discussion

Knowledge networks support individuals coming together across an organization to develop and share ideas and knowledge. A teacher professional knowledge building network provides opportunities for teachers to engage collectively in the continuous

development of purposeful and effective instructional strategies. The development and improvement of teacher professional practice cannot be achieved through a set of quick-fix workshops or simple resource sharing. For teachers to effectively develop and improve their practice, they need opportunities to continually explore, share, create, and build professional knowledge together in an safe and collaborative environment.

Reflections on the Research Process

The development of a network tool to provide opportunities for rural teachers across a geographically vast school district to connect and build resources was a major strength of this research. Teachers in this specific rural school district often experience isolation and lack of opportunities to meet and work collaboratively with their colleagues. Introducing a networked environment where teachers could develop and share knowledge helped support responsive professional learning that initiated the development of a broader professional knowledge building community.

The implementation of both the pilot study and the larger case study stimulated a high response rate. This yielded a high volume of data that enabled a detailed account of multiple experiences of teachers across different subject areas and grade levels. The diversity of participants and multiple data sources helped me have a better understanding of the level of personalization teachers require when building and sharing knowledge. I was also able to extrapolate from server log data an intricate picture of the complex individual interactions and knowledge building behaviours of teachers in the network.

I believe a major strength of this research study is that I designed my own network tool based on the conceptual framework created for this research study. This allowed me to customize the tool and be responsive to the needs of my research

participants. When knowledge inhibitors were identified during the study, or personalization features were needed to better support shared knowledge creation, I could modify and enhance the tool, while still maintaining the theoretical propositions that I had identified earlier in my literature review. I was also able to provide a specific Alberta context for teachers in the network by codifying Knowledge Artefacts by Alberta curricular outcomes.

Several challenges emerged during the study. Perhaps the greatest challenge was the disengagement of expert and master teachers in the knowledge building process. Even though customizations were made to the digital tool to encourage greater knowledge building and sharing, most expert and master teachers were still unwilling to connect with other colleagues in the network. This negatively impacted the level of knowledge constructed in the network and, at times, interrupted the flow and diffusion of ideas by other network members.

Little (2004) suggested that the conditions for improving teacher learning are strengthened when teachers collectively question ineffective teaching practices and collaboratively develop new alternatives. Developing capacity for teacher collaborative inquiry means creating safe spaces where teachers can openly discuss professional challenges and express differing views and opinions. Collaborative inquiry that challenges teacher professional practice is not easy because it involves teachers making explicit what they know and do not know and using their professional challenges as a springboard for generating and exploring new ideas.

This level of interaction presumes a high level of trust between teachers in the network. Throughout this case study, the important role of trust was clearly identified by

teachers as an essential component of effective shared knowledge creation in both questionnaire and interview data. Teachers consistently commented that, for knowledge sharing to be successful, they need to feel safe and not afraid to be vulnerable with one another when tackling real issues and challenges within their individual professional practice. Developing this level of trust in a networked environment proved to be a challenge for this research. Offline interactions and face-to-face meetings were commonplace among Knowledge Teams, but developing those deeper connections, and the higher-level interactions that are needed for sustained idea exploration and knowledge sharing, often proved difficult in the network.

Implications of the Research

The findings from this research study have implications for teachers, leaders, and educational technologists concerned with developing an effective teacher professional knowledge building network. In the closing sections of this chapter, implications from this research with regards to teacher expertise and effective knowledge sharing are outlined and specific leadership structures are discussed that support the development and sustainability of a knowledge sharing culture. Design implications for the development of a knowledge building network are also presented.

Teachers as shared Knowledge Builders. One of the intriguing findings that emerged from this research is that knowledge sharing among teachers involves different types of collaborative inquiry. The foundational research of Scardamalia and Bereiter (1994) emphasized that knowledge building contexts need to focus on problems rather than on categories or topics; in a knowledge building community, knowledge work is about sharing ideas and advancing theories. The findings from this research suggest that

teachers initiate knowledge creation through collaborative inquiry concerning professional problems and challenges, but they also use current Knowledge Artefacts as triggers that advance and innovate individual professional practice gaps. This means that knowledge building networks focused on teacher professional development need to have specifically designed features that support deep collaborative discourse environments as well as meaningful shared Knowledge Artefacts.

Another important implication drawn from this research with regards to teacher-shared knowledge creation is the role of teacher expertise. Teacher professional development is a career-long endeavour that is often guided by changes in pedagogy and district initiatives, and focuses on improved student learning. For teacher professional learning to be meaningful, it must meet the needs of a variety of professionals throughout their various career stages.

Additionally, if teachers are to effectively engaged in knowledge building and sharing in a networked environment, there must be opportunities for them to interact with knowledge, artefacts, and shared practices that are meaningful to their individual teacher practice. Most of the expert and master teachers who participated in this study felt that the network did not provide knowledge or resources that were valuable to the improvement of their professional practice.

Moving forward, if knowledge building networks are to be effective, they must provide multiple entry points for teachers that address a variety of professional practice issues. The digital tool for this study was organized by curricular outcome, but an additional feature that expert and master teachers felt was needed was pedagogical content organized by various professional issues and highly specialized content areas.

Most experienced teachers felt they would engage more often in the network if it included discussions and resources that aligned with current issues related to the teaching profession. Expert teachers also indicated that the development and sharing of highly specialized knowledge across various grade levels and topic areas would encourage them to participate more fully in the network.

Leadership can help support better knowledge sharing. Knowledge networks provide a space for teachers to pursue shared knowledge building, but teachers often find it difficult to devote attention to pervasive knowledge building because of the multiple responsibilities and initiatives running throughout the school district. For knowledge building to be effective, there needs to be a shift in the role of leaders for networking initiatives to be sustainable.

Traditional top-down leadership models rarely build the kind of internal commitment needed to develop and nurture a knowledge building culture because knowledge creators often become dependent on district leaders to determine and manage the types of knowledge that will be created and shared. In contrast, Nonaka and Takeuchi (1995) suggested that often top-down leadership models view knowledge as something that is created by individuals and shared as information products. To capture the dynamic aspects of effective knowledge creation that are often built between individuals and across teams, they believe a middle-up approach is more effective. In middle-up leadership models, lateral capacity is built by distributing the leadership through an organizational system by embedding it within organizational culture.

For knowledge building and networking to be successful, school districts need teachers, administrators, and divisional leaders to become invested in creating a culture of

shared knowledge creation. The leaders of a knowledge building network need to come from within and across a school district at all levels. Formal leaders as well as informal leaders can encourage participation in the network and help define the network's purpose. These same leaders recognize that knowledge building and sharing is personal for teachers and a safe space must be created where even the most experienced teacher is open to being vulnerable and improving their professional practice.

Teachers need high levels of trust in order to engage deeply in knowledge building; Knowledge Leaders within the network can help support and nurture high levels of trust over time through the interactions and connections they make in the network. Leaders outside the network can build engagement by inviting individuals to join the network and support knowledge sharing by connecting teachers and sharing successful knowledge creation work within their schools and districts.

Knowledge building networks require personalization. The interactions and knowledge sharing behaviours of teachers in the network demonstrated that shared knowledge building is an individualistic experience for teachers. Just like one-size-fits-all solutions are not effective with regards to teacher professional development, the same is true with regards to a teacher professional knowledge building network. Data from the case study indicated that teachers required a digital space that was responsive to their individual professional needs, while still providing multiple opportunities to connect and collectively build and share knowledge with other network members.

The findings from this study provide valuable information with regards to the design and sustainability of a teacher professional knowledge building network. A key

distinction that emerged from the research findings is the difference between codification and personalization in the development of a knowledge building network.

In larger organizations, such as school districts, knowledge resources are collected, codified, and stored in databases and repositories for easy access. The problem with codification is that it assumes that Knowledge Artefacts are in a dormant state, no longer accessed for future innovation and improvement. Knowledge building networks need opportunities that allow shared Knowledge Artefacts to be transformed, improved, and developed. Shifting the purpose of a network from a database or repository of codified knowledge requires a movement towards higher levels of personalization. In network environments, personalization focuses on communication and social structures that support the mediation of shared Knowledge Artefacts (Boh, 2007). Personalization provides multiple and diverse opportunities for individuals to explore ideas, share knowledge, and co-construct artefacts. With personalization, networks need to be open, flexible, and promote transparency.

Recommendations for Future Research

Two key recommendations for future research were identified from the findings and conclusions of this case study: 1) exploring the impact of teacher expertise and knowledge reciprocity, and 2) developing and nurturing trust to support sustained knowledge sharing among teachers.

First, further research is needed to better understand how teacher expertise impacts knowledge building and sharing. The case study findings indicated that teachers with higher levels of knowledge expertise were more resistant to share and contribute to a knowledge building network. While there is some research that focused on the

distribution of expertise in relation to knowledge transfer (Cohen & Levinthal, 1990), less research is dedicated to exploring how teacher expertise is integrated into the knowledge creation process and the impact of teacher expertise on knowledge reciprocity in a professional knowledge building network. Key questions that still need to be answered in relation to teacher expertise are: 1) What are the main inhibitors that prevent expert teachers from building and sharing knowledge in a networked environment? and 2) How do teachers with different expertise and professional contexts engage in shared knowledge building? A closer examination of these questions could provide a better understanding of the role teacher expertise plays in effective shared knowledge creation.

Second, the findings from my research also suggest that there needs to be a better understanding of the role and development of trust in networked professional learning and knowledge building. Much research has focused on collaboration and trust within virtual teams (Tschannen-Moran, 2001; Jarvenpa, Shaw & Staples, 2004), but less research has focused on the high levels of trust that need to be developed with regards to knowledge building in networked environments. The findings from my research suggests that there is a need for further exploration of how trust impacts the relationships and interactions developed in networked environments and the impact of trust on teacher-shared knowledge building.

Conclusion

For many years, teachers have been passive participants in professional development. They often attend workshops and conferences to acquire information and expertise. Rarely has teacher professional learning seen teachers come together collectively to share and develop knowledge. Professional knowledge building networks

support the belief that system improvement means whole systems connecting and learning together. It is hoped that this research will provide an opportunity to develop a knowledge building framework that can support the evolving nature of learning and knowledge building, while also responding to the changing dynamics of effective teacher professional development. A professional learning network where individual needs can be authentically addressed in a context focused environment will move the focus of a professional development framework from integrating technology into a professional learning community, to building and supporting a knowledge building community. A professional knowledge building network provides a new landscape where teachers have multiple opportunities to create as well as receive knowledge. More importantly, the knowledge associated with improved instructional teaching practice is no longer developed by outside experts or individually owned, but is collectively developed through multiple teacher interactions and shared experiences. Schlager and Fusco (2003) remind us as we move towards a collective purpose with regards to professional development, to view learning communities as "emergent, self-reproducing, and evolving entities that are distinct from, and frequently extend beyond, formal organizational structures, with their own organizing structures, norms of behavior, communication channels, and history" (p. 204). A knowledge building network has the potential to empower teachers to come together to build and develop their skills and expertise as a collective community.

We are at the dawn of a new era of professional learning for teachers. We have the technology to promote sustained knowledge building, but there needs to be an essential mind shift for both teachers and educational leaders. Teachers need to see

themselves as a community of professionals building and sharing their skills and expertise to continually advance and develop the professional of teaching. Leaders need to embrace a new professional development model that encourages pervasive idea exploration and knowledge sharing. This means that professional development can no longer be viewed as episodic events, isolated days, or workshops. Instead, professional learning needs to occur throughout the year in an asynchronous environment that continuously responds to the needs of the teachers within a knowledge building community.

The development of the digital tool, Knowledge Net, for this study was an immense personal endeavour. The network required technological support, training, and customization to be effective and responsive to the needs of the knowledge building community. If educational organizations recognize the value of teachers building and sharing their professional knowledge to increase the collective wisdom within an organization, then school districts must be willing to invest in knowledge building software and be committed to supporting the sustainability of the tool.

I believe this study has contributed to the understanding of teachers as shared Knowledge Builders. For professional learning communities to transform into professional knowledge building communities, a culture of idea exploration and knowledge sharing must become an integral part of a teacher's ongoing professional learning. A shift that will be required to successfully support teacher professional knowledge building is creating meaningful opportunities for teachers to co-construct knowledge through an accumulation of individual expertise and prior knowledge. This means providing structures where novice teachers are actively engaging and sharing

knowledge with more experienced teachers to continually develop the profession of teaching.

An important finding from this research is that shared knowledge creation is a personal endeavour for teachers and requires a high level of trust in order to support the deeper collaboration required to engage in the real ideas and authentic professional challenges that are necessary for effective shared knowledge creation. Creating a virtual environment that can support this high level of trust and deep collaboration is challenging and requires multiple opportunities for teachers to connect with other teachers. More importantly, knowledge building networks have the potential to redefine teacher professional development from a focus on individual knowledge acquisition to the development of dynamic shared knowledge building communities.

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APPENDIX A: PRE-ASSESSMENT QUESTIONNAIRE

REAL IDEAS, AUTHENTIC PROBLEMS

My professional development opportunities create a culture for me to do creative work with various ideas. There are opportunities for me to reflect of on the core work of the organization and of my ideas as an educator.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

IMPROVABLE IDEAS

My professional development opportunities reflect changes in teaching and learning, provide opportunities for continual improvement of ideas and my own teacher practice,

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

IDEA DIVERSITY

My professional development opportunities provide opportunities for ideas diversity and provide opportunities for me to interact with my colleagues to explore new ideas.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

RISE ABOVE

My professional development opportunities create situations were groups of teachers are working together towards a higher understanding. In this environment, colleagues can synthesize new ideas together and move beyond current best practice to co-construct new knowledge.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

EPISTEMIC AGENCY

My professional development opportunities allow me and other participants to set forth their ideas and negotiate a fit between personal ideas and the ideas of others, using contrasts to spark and sustain knowledge advancement rather than depending on others to chart that course for them.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

COMMUNITY KNOWLEDGE, COLLECTIVE RESPONSIBILITY

My professional development opportunities celebrate and reward individual achievements. Team members produce ideas of value to others and share responsibility for the overall advancement of knowledge in the community.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

CONSTRUCTIVE USES OF AUTHORITATIVE SOURCES

My professional development opportunities encourage me to use authoritative sources, along with other information sources, as data for my own knowledge building and idea-improving processes. I am encouraged to contribute new information to a central area for sharing.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

KNOWLEDGE BUILDING DISCOURSE

My professional development opportunities result in more than sharing of knowledge. Instead, my colleagues and I are asked to identify shared problems and gaps in understanding and to advance understanding beyond the level of the most knowledgeable individual in the room.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

EMBEDDED AND TRANSFORMATIVE ASSESSMENT

My professional development opportunities often use a form of internal assessment to

identify problems as the group's work proceeds and is embedded throughout professional development.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

APPENDIX B: KNOWLEDGE NET DESIGN QUESTIONNAIRE

Knowledge Net is the knowledge building network has been created to support this research study. The tools within Knowledge Net will be evaluated and redesigned based on your ongoing feedback. Please take a moment to complete the following questionnaire, which will provide input on how effectively Knowledge Net is supporting your knowledge building experience.

REAL IDEAS & AUTHENTIC PROBLEMS

Knowledge problems arise from our efforts to understand the world around us. Problems that provide the greatest promise of knowledge building are those that Knowledge Builders really care about because they are relevant to their lives.

Please rate Knowledge Net's ability to support the development of real ideas focused on authentic problems.

1. Knowledge Net creates an easy environment for creative and personal work around idea development and sharing.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

2. The tools in Knowledge Net (e.g. My Wonderings, Idea Builds and Knowledge Teams) provide me with opportunities for direct reflection as well as idea creation.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

3. Knowledge Net provides an easy platform for teachers to discuss, tackle and solve authentic problems.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

IMPROVABLE IDEAS

Effective knowledge building requires a safe arena where knowledge building members can share, build and co-create ideas together, while constantly reflecting and improving on those ideas.

Please rate Knowledge Net's ability to create and support the improvement of ideas.

4. In Knowledge Net ideas have the ability to be improved by other teachers.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

5. Knowledge Net provides opportunities for teachers to revise, build, explore, and continually improve ideas.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

6. Knowledge Net has provided a safe environment for teachers where shared Idea Building and risk taking are embraced and celebrated within the knowledge building community.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

IDEA DIVERSITY

Idea diversity is essential to effective knowledge advancement. In order to develop knowledge, we must understand all facets of an idea and all the ideas that surround it. Idea diversity creates a rich environment for the evolution of ideas and the refinement of those ideas.

Please rate Knowledge Net's ability to support idea diversity.

7. Knowledge Net provides opportunities for teachers to post their ideas at all stages of knowledge construction. (e.g. My Wonderings, Idea Builds, Artefact Repository)

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

8. Knowledge Net supports idea diversity by facilitating idea linking through knowledge construction so that combinations of ideas can effectively and easily be brought together in different Idea Builds.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

9. Idea Builds within Knowledge Net provide teachers with opportunities to explore ideas from a variety of viewpoints.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

RISE ABOVE & SCAFFOLDING OF IDEAS

Creative knowledge building construction requires building and working towards higher-level understandings of problems and ideas. Effective knowledge building requires synthesis and the ability to move to higher levels of knowledge construction.

Please rate Knowledge Net's ability to support idea diversity.

10. Knowledge Net provides teachers with opportunities to scaffold their ideas and embed new ideas within an Idea Build.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

11. The tools within Knowledge Net support emergent and organic development of Idea Building and knowledge construction and do not control or inhibit knowledge building.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

12. Knowledge Net provides opportunities for ideas to be linked and shared with other members of the knowledge building community.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

EPISTEMIC AGENCY

Effective Knowledge Building requires that all knowledge building members set forth their own ideas, negotiate personal ideas with the ideas of others and use contrast to spark discussion that seeks to advance knowledge within the knowledge building community.

Please rate Knowledge Net's ability to supports epistemic agency within its networked environment.

13. Knowledge Net effectively provides opportunities for teachers to sort and organize Wonderings and posts so that discussions of interest are easily found.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

14. Higher-level knowledge processes such as conjecture, wonder and hypothesis are effectively supported by Knowledge Net as the initial building blocks for idea development.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

15. Knowledge Net provides opportunities for idea discussion, contrast and conjecture and supports the development of these knowledge building advancements within its platform.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

KNOWLEDGE COMMUNITY & COLLECTIVE RESPONSIBILITY

Shared knowledge building requires that co-constructed knowledge be shared with other members within the knowledge building community. These newly created Knowledge Artefacts represent the collective shared knowledge of a group of Knowledge Builders and provide opportunities for the overall advancement of knowledge for the entire community.

Please rate Knowledge Net's ability to support the development of a knowledge community and collective responsibility within its networked environment.

16. Knowledge Net provides an open collaborative workspace for teachers to develop, refine, share, and build upon one another's ideas.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

17. Knowledge Net provides an effective Artefact Repository for teachers to share and collect knowledge artefacts.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

18. Knowledge Net effectively provides opportunities for knowledge building members to create, share, and build knowledge together.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

KNOWLEDGE BUILDING DISCOURSE

The discourse of knowledge building communities results in more than the sharing of knowledge; the knowledge itself is refined and transformed through the discursive practices of the community, where the advancement of knowledge is the community's explicit goal.

Please rate Knowledge Net's ability to support constructive uses of authoritative sources within its networked environment.

19. Knowledge Net Provides opportunities for teachers to share problems and gaps with regards to professional practice.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

20. Knowledge Net provides supports individual risk taking with regards to knowledge building discourse.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

21. Knowledge Net effectively advances discourse beyond the level of the most knowledgeable individual within the discussion.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

CONSTRUCTIVE USES OF AUTHORITATIVE SOURCES

In order to build on knowledge, it is important to be in touch with the present state and growing edges of research and evidence related to the ideas and the knowledge that is being constructed. It is important that members have a strong understanding of the authoritative sources as well as the ability to take a critical stance of the viewpoints that exist with regards to the ideas being developed and improved within the knowledge building community.

Please rate Knowledge Net's ability to support constructive uses of authoritative sources within its networked environment.

22. Knowledge Net encourages teachers to use authoritative sources, along with other information sources as part of their own idea-improving processes.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

23. Teachers can easily integrate authoritative sources into their Idea Builds

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

24. Teachers can easily identify other teacher professionals and connect with them as authoritative sources for knowledge building within the network.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

EMBEDDED & TRANSFORMATIVE ASSESSMENT

Assessment can help advance knowledge within a knowledge building community and is used to identify problems with new knowledge constructions as well as fine-tune knowledge as it continues to be shared and developed.

Please rate Knowledge Net's ability to support embedded and transformative assessment within its networked environment.

25. Knowledge Net effectively provides internal assessment of knowledge artefacts for the knowledge building community.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

26. Knowledge Net allows teachers opportunities to provide feedback on Idea Builds and completed knowledge artefacts.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

27. Knowledge Net allows for Knowledge Builders to assess the completeness of an Idea Build or Knowledge Artefact within the network.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

APPENDIX C: MY WONDERINGS PARTICIPANT QUESTIONNAIRE

As a member of Knowledge Net, please take a moment to complete the following questionnaire regarding the evolution of your Wondering with the My Wonderings Discussion Forum.

Please rate Knowledge Net's ability to support the development of real ideas focused on authentic problems.

1. Wonderings provided an opportunity to grapple with problems posed by the knowledge building community.

   ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

2. Teacher-to-Teacher Wonderings promote increased knowledge building.

   ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

3. Wonderings provided an opportunity for teachers to share outside resources that promote continual knowledge building.

   ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

4. Wonderings encouraged other Knowledge Builders to continue and extend discussions.

   ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

5. The Wonderings discussion area extended the edges of a knowledge building community's collective understandings.

   ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

6. Show sustained inquiry from the knowledge building community by identifying problems while also attempting to continually solve problems and ask questions centered on problems.

   ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

7. Encourage other knowledge building members to join other Idea Builds that share similar ideas.

   ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

8. Encourage other knowledge building members to join other Idea Builds that share similar ideas.

   ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

9. Promote inclusion of other knowledge building members by inviting other participants to join in an Idea Build.

   ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

10. The Wonderings discussion area encourages a sense of community within the network.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

APPENDIX D: KNOWLEDGE TEAM PARTICIPANT QUESTIONNAIRE

As a member of Knowledge Net, please take a moment to complete the following questionnaire regarding your participation in Knowledge Teams

Please fill in the bubble next to the descriptors that you feel best describes your engagement with Knowledge Teams in Knowledge Net.

1. Knowledge Teams successfully promoted knowledge building and idea exploration of real problems among other knowledge members.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

2. Knowledge Builders built and improved the ideas and beliefs of the Knowledge Team.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

3. The Knowledge Team provided opportunities to work at the cutting edges of ideas that were of interest to me.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

4. Team members continually build on the ideas of others to advance the general knowledge of the whole team.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

5. Sometimes I changed my beliefs based on the ideas and contributions of other Knowledge Builders.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

6. Knowledge Builders supported and encouraged one another within the Knowledge Teams.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

7. I was actively involved in contributing to the Knowledge Team discussions.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

8. Team Members shared outside resources that promoted team knowledge building.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

9. I often provided feedback to move team ideas to the highest level of knowledge creation.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

10. I would rate the level of knowledge building within my group as

○ Very High ○ High ○ Low ○ Very Low

11. I would rate the level of collaborative interactions within my group as

○ Very High ○ High ○ Low ○ Very Low

APPENDIX E: IDEA BUILDING PARTICIPANT QUESTIONNAIRE

As a member of Knowledge Net, please take a moment to complete the following questionnaire regarding the evolution of Idea Builds within Knowledge Net.

Please fill in the bubble next to the descriptors that you feel best describes your Idea Builds in Knowledge Net.

P1: Working at the Cutting Edge

REAL IDEAS & AUTHENTIC PROBLEMS

Knowledge problems arise from our efforts to understand the world around us. Problems that provide the greatest promise of knowledge building are those that Knowledge Builders really care about because they are relevant to their lives.

Your Idea Builds…

1. Identify knowledge gaps and inconsistencies within the knowledge building community.

   ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

2. Continually focus on advancing and improving ideas.

   ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

3. Extend the edges of a knowledge building community's collective understandings.

   ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

4. Invites other Knowledge Builders to continue and extend discussions and inquiry.

   ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

P2: Progressive Problem Solving

IMPROVABLE IDEAS

Effective knowledge building requires a safe arena where knowledge building members can share, build and co-create ideas together, while constantly reflecting and improving on those ideas.

Your Idea Builds…

5. Demonstrate continual efforts to grapple with problems posed by the knowledge building community.

   ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

6. Address original problems and questions that appear within Knowledge Net.

   ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

7. Show sustained inquiry from the knowledge building community by identifying problems while also attempting to continually solve problems and ask questions centered on problems.

   ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

8. Reinvests the efforts of the knowledge building community by solving new problems that arise within the knowledge building community, while continually working towards improving original ideas.

   ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

P3: Constructive Uses of Authoritative Sources

CONSTRUCTIVE USES OF AUTHORITATIVE SOURCES

To build on knowledge, it is important to be in touch with the present state and growing edges of research and evidence related to the ideas and the knowledge that is being constructed. It is important that members have a strong understanding of the authoritative sources as well as the ability to take a critical stance of the viewpoints that exist with regards to the ideas being developed and improved within the knowledge building community.

Your Idea Builds…

9. Use information from different sources (e.g., Internet, research journals, learning theory) to support, explain and refute ideas.

O Strongly Agree O Somewhat Agree O Somewhat Disagree O Strongly Disagree

10. Connects the knowledge created within the knowledge building community with learning from other Knowledge Net Wonderings.

O Strongly Agree O Somewhat Agree O Somewhat Disagree O Strongly Disagree

11. Accesses the ideas of other Knowledge Builders within the network.

O Strongly Agree O Somewhat Agree O Somewhat Disagree O Strongly Disagree

12. Extends on shared artefacts and ideas within the network.

O Strongly Agree O Somewhat Agree O Somewhat Disagree O Strongly Disagree

P4: Collaborative Effort

KNOWLEDGE COMMUNITY & COLLECTIVE RESPONSIBILITY

Shared knowledge building requires that co-constructed knowledge be shared with other members within the knowledge building community. These newly created Knowledge Artefacts represent the collective shared knowledge of a group of Knowledge Builders and provide opportunities for the overall advancement of knowledge for the entire community.

Your Idea Builds…

13. Uses various functions and tools from Knowledge Net to make knowledge accessible during Idea Building.

O Strongly Agree O Somewhat Agree O Somewhat Disagree O Strongly Disagree

14. Summarizes different ideas and viewpoints and put them together to create a better understanding.

    ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

15. Helps other knowledge building members to extend and improve their understanding.

    ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

16. Encourages other knowledge building members to join other Idea Builds that share similar ideas.

    ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

17. Promotes inclusion of other knowledge building members by inviting other participants to join in an Idea Build.

    ○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

APPENDIX F: POST-ASSESSMENT QUESTIONNAIRE

REAL IDEAS, AUTHENTIC PROBLEMS

My professional development opportunities create a culture for me to do creative work with various ideas. There are opportunities for me to reflect of on the core work of the organization and of my ideas as an educator.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

IMPROVABLE IDEAS

My professional development opportunities reflect changes in teaching and learning, provide opportunities for continual improvement of ideas and my own teacher practice,

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

IDEA DIVERSITY

My professional development opportunities provide opportunities for ideas diversity and provide opportunities for me to interact with my colleagues to explore new ideas.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

RISE ABOVE

My professional development opportunities create situations were groups of teachers are working together towards a higher understanding. In this environment, colleagues can synthesize new ideas together and move beyond current best practice to co-construct new knowledge.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

EPISTEMIC AGENCY

My professional development opportunities allow me and other participants to set forth their ideas and negotiate a fit between personal ideas and the ideas of others, using contrasts to spark and sustain knowledge advancement rather than depending on others to chart that course for them.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

COMMUNITY KNOWLEDGE, COLLECTIVE RESPONSIBILITY

My professional development opportunities celebrate and reward individual achievements. Team members produce ideas of value to others and share responsibility for the overall advancement of knowledge in the community.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

CONSTRUCTIVE USES OF AUTHORITATIVE SOURCES

My professional development opportunities encourage me to use authoritative sources, along with other information sources, as data for my own knowledge building and idea-improving processes. I am encouraged to contribute new information to a central area for sharing.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

KNOWLEDGE BUILDING DISCOURSE

My professional development opportunities result in more than sharing of knowledge. Instead, my colleagues and I are asked to identify shared problems and gaps in understanding and to advance understanding beyond the level of the most knowledgeable individual in the room.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

EMBEDDED AND TRANSFORMATIVE ASSESSMENT

My professional development opportunities often use a form of internal assessment to

identify problems as the group's work proceeds and is embedded throughout professional development.

○ Strongly Agree ○ Somewhat Agree ○ Somewhat Disagree ○ Strongly Disagree

APPENDIX G: SEMI-STRUCTURED INTERVIEW QUESTIONS

Face-to-Face Interviews will be conducted by the researcher on all Knowledge Builders from the five Knowledge Team that have been selected within the research study.

Time of Interview:

Date:

Interviewer:

Participant No:

Notes for Interviewer:

Describe briefly the project, tell the interviewee about (a) the purpose of the study, (b) the individuals and sources of data being collected, (c) what will be done with the data to protect the confidentiality of the interviewee, and (d) how long the interview will take.

Have the interviewee read and sign the consent form.

Turn on the tape recorder and test it.

Questions:

1. Briefly explain how you acquired knowledge about your profession before this research project?
2. As you began to use Knowledge Net more frequently have you found that you seek different sources of knowledge or use knowledge in a different way?
3. Can you explain what you believe is involved in the process of effective shared knowledge building?
4. What have you learned about yourself as a Knowledge Builder as you have worked within Knowledge Net?
5. What are some challenges you have encountered as you have shared and created knowledge with other participants?
6. What do you believe is the most important characteristic of successful shared knowledge creation?
7. How did your experience with Knowledge Net impact you as an educator?
8. Can you provide an example of a knowledge building experience that you had during this research study?
9. How do you feel professional learning leads and divisional leaders can best support shared knowledge creation within the school district?
10. Do you feel there is a clear vision for the creation and sharing of knowledge by teachers within the school division?

APPENDIX H: CARD SORTING SCRIPT

Date:

Interviewer:

Participant No:

Script to be read before the Knowledge Building Principles Card Sort:

This first card sort will focus on your perceptions of the shared knowledge creation process with relation to nine Knowledge Building Principles. You will be presented with a stack of nine index cards that I will shuffle in front of you. Each card has the title of a knowledge building principle on one side and its corresponding definition on the other. I will also provide you with several blank cards and a marker. I will also provide you with a set of instructions to help you perform this closed sort.

1) Organize the cards in a chronological order that best reflects their personal experience of shared knowledge building within a networked environment;
2) Talk through the card sorting process, stating rationales for placement of cards;
3) Set aside any cards that they feel are not a part of their knowledge building process;
4) Use the blank cards provided to create new cards for anything the interviewees felt was missing from the process.

Please not that I will be talking notes during your sort and at the end I will record your final sort and include any omissions or inclusions that you have provided.

---

1. Real Ideas and Authentic Problems
2. Improvable Ideas
3. Idea Diversity
4. Rise Above and Scaffolding of Ideas
5. Epistemic Agency
6. Knowledge Community and Collective Responsibility
7. Knowledge Building Discourse
8. Constructive Uses of Authoritative Sources
9. Embedded Transformative Assessment

Script to be read before the Knowledge Building Inhibitor Card Sort:

This second card sort will build on the cards that you have just sorted so they will remain in front of you. This card sort will focus on your perceptions of Knowledge Building Inhibitors that have impacted your ability to successful share and build knowledge within the network. You will be presented with a new stack of nine index cards that I will shuffle in front of you. Each card has the title of a knowledge building inhibitor on one side and its corresponding definition on the other. I will also provide you with several blank cards and a marker. I will also provide you with a set of instructions to help you perform this closed sort.

1) Rank and prioritize the cards according to the Knowledge Building Inhibitors they felt had the greatest impact on their knowledge building experiences;
2) Talk through their card sort and provide any rationales or comments as they organized the nine cards;
3) Set aside any cards that they felt did not inhibit their knowledge building experience;
4) Use the blank cards provided to create new cards for any Knowledge Building Inhibitors the interviewees felt were missing from the sort.

Please note that I will be talking notes during your sort and at the end I will record your final sort and include any omissions or inclusions that you have provided.

-Recordings

1. Connective Efficacy
2. Group Identification
3. Knowledge Classification and Codification
4. Knowledge Contribution
5. Knowledge Self-Efficacy
6. Offline Interactions
7. Personal Identify Verification
8. Professional Evaluation Apprehension
9. System Quality

Finally, I would like you to align the Knowledge Building Inhibitors with the knowledge building principles that they most impact. Please take a moment and place the Knowledge Building Principles underneath the Knowledge Building Inhibitors that you feel are most impacted

APPENDIX I: KNOWLEDGE BUILDING PRINCIPLE CARDS

Real Ideas and Authentic Problems	Knowledge problems arise from our efforts to understand the world around us. Problems that provide the greatest promise of knowledge building are those that Knowledge Builders really care about because they are relevant to their lives
Improvable Ideas	Effective knowledge building requires a safe arena where knowledge building members can share, build and co-create ideas together, while constantly reflecting and improving on those ideas.
Idea Diversity	Idea diversity is essential to effective knowledge advancement. In order to develop knowledge, we must understand all facets of an idea and all the ideas that surround it. Idea diversity creates a rich environment for the evolution of ideas and the refinement of those ideas.

Rise Above and Scaffolding of Ideas	Creative knowledge building construction requires building and working towards higher-level understandings of problems and ideas. Effective knowledge building requires synthesis and the ability to move to higher levels of knowledge construction.
Epistemic Agency	Effective Knowledge Building requires that all knowledge building members set forth their own ideas, negotiate personal ideas with the ideas of others and use contrast to spark discussion that seeks to advance knowledge within the knowledge building community.
Knowledge Community and Collective Responsibility	Shared knowledge building requires that co-constructed knowledge be shared with other members within the knowledge building community. These newly created Knowledge Artefacts represent the collective shared knowledge of a group of Knowledge Builders and provide opportunities for the overall advancement of knowledge for the entire community.

Knowledge Building Discourse	The discourse of knowledge building communities results in more than the sharing of knowledge; the knowledge itself is refined and transformed through the discursive practices of the community, where the advancement of knowledge is the community's explicit goal.
Constructive Uses of Authoritative Sources	In order to build on knowledge, it is important to be in touch with the present state and growing edges of research and evidence related to the ideas and the knowledge that is being constructed. Members need to have a strong understanding of authoritative sources as well as the ability to take a critical stance of the viewpoints that exist with regards to the ideas being developed and improved within the knowledge building community.
Embedded and Transformative Assessment	Assessment can help advance knowledge within a knowledge building community and is used to identify problems with new knowledge constructions as well as fine-tune knowledge as it continues to be shared and developed.

APPENDIX J: KNOWLEDGE BUILDING INHIBITOR CARDS

Connective Efficacy	The belief that other people who can use the contributed knowledge will receive it and build upon it.
Group Identification	An individual's sense of belonging and identity within a network.
Knowledge Classification & Codification	The time and effort required to codify and input knowledge.

Knowledge Contribution	The perception of increased individual reputation within the network based on knowledge contributions.
Knowledge Self-Efficacy	The belief that an individual's participation and knowledge contributions will make a difference to the success and value of knowledge building community.
Offline Interactions	The degree to which network members participate in offline activities related to the network and knowledge development.

Personal Identity Verification	The perceived confirmation from other members of the network of a member's beliefs, values and contributions within the network.
Professional Evaluation Apprehension	A member's active anxiety that his or her knowledge contributions will be critiqued or evaluated within the network.
System Quality	The extent to which an individual perceives that a particular system is free of effort, easy to use and effectively supports the members within a network and their focused work.

APPENDIX K: Case Study Codebook

Phase I & II: Coding Posted Wonderings

PHASE I:	**SHARING/COMPARING OF INFORMATION**	
	Operations at this stage include:	
A.	A statement of observation, opinion in the form of a wondering	[Ph1/A]
B.	A statement of agreement from one or more other participants	[Ph1/B]
C.	Corroborating wonderings and examples provided by one or more participants	[Ph1/C]
D.	Asking and answering questions to clarify details of participant wonderings	[Ph1/D]
E.	Definition, description, or identification of a problem within a wondering	[Ph1/E]
PHASE II:	**THE DISCOVERY AND EXPLORATION OF DISSONANCE OR INCONSISRENCY AMONG IDEAS, CONCEPTS OR STATEMENTS.**	
	Operations at this stage include:	
A.	Identifying and stating areas of disagreement within participant wonderings.	[Ph2/A]
B.	Asking and answering questions to clarify the source and extent of disagreement within a wondering.	[Ph2/B]
C.	Restating the participant's wondering, and possibly advancing it by connecting it to participant experience, literature, formal data collected, or a relevant metaphor or analogy to strengthen a point of view.	[Ph2/C]
PHASE III:	**NEGOTIATION OF MEANING/CO-CONSTRUCTION OF KNOWLEDGE**	
	Operations at this stage include:	
A.	Negotiation or clarification of a wondering.	[Ph3/A]
B.	Negotiation of the relative weight to be assigned to a wondering.	[Ph3/B]
C.	Identification of areas of agreement or overlap among conflicting wonderings.	[Ph3/C]
D.	Proposal and negotiation of new statements embodying compromise and co-construction of wonderings.	[Ph3/D]
E.	Proposal of integrating or accommodating metaphor, analogies or wonderings.	[Ph3/E]
PHASE IV:	**TESTING AND MODIFICATION OF PROPOSED SYNTHESIS OR CO-CONSTRUCTION**	
	Operations at this stage include:	
A.	Testing the proposed wondering against "received fact" as shared by the participants and/or their culture.	[Ph4/A]
B.	Testing a wondering against existing cognitive schema.	[Ph4/B]
C.	Testing a wondering against personal experience.	[Ph4/C]
D.	Testing a wondering against formal data collected.	[Ph4/D]
E.	Testing a wondering against contradictory testimony in literature.	[Ph4/E]
PHASE V:	**AGREEMENT STATEMENT(S)/APPLICATIONS OF NEWLY-CONSTRUCTED MEANING**	
	Operations at this stage include:	
A.	Summarization of agreement(s) by rising above to an idea build.	[Ph5/A]
B.	Participants that actively join an idea build.	[Ph5/B]
C.	Metacognitive statements by participants illustrate interactions with participants wonderings, have changed their cognitive schema and have moved them toward shared idea and meaning making.	Ph5/C]

Interaction Analysis Model for Examining Social Construction of Knowledge. Adapted from Gunawardena, Lowe, & Anderson. (1997).

PHASE III: Determining the level of shared knowledge constructed within the network

Knowledge Label	Weight	Description
Representative Knowledge	1	Artefacts come from external authoritative sources such as a published teacher resource or pedagogical program.
Personally Constructed Knowledge	2	Individual knowledge and expertise is developed into a knowledge Artefact.
Semi-Autonomous Knowledge	3	Knowledge and expertise is combined between two individuals to develop a shared knowledge artefact.
Collective Knowledge	4	Knowledge creating groups share their knowledge and expertise to create a co-constructed knowledge Artefact.
Transformative Knowledge	5	Pervasive idea exploration and collaborative knowledge advancement develop innovative knowledge artefacts.

PHASE IV: Analyzing the Impact of Internal Community Knowledge

Knowledge Artefact Assessment Principles	Weight	Description
Working at the Cutting Edges	1	Identifying knowledge gaps while extending the edges of professional knowledge
Constructive sue of Authoritative Sources	2	Use of information from a variety of external resources to support ideas.
Progressive Problem Solving	3	Demonstrate continual idea development and exploration Scaffold and build on the understandings and ideas of other network members.
Collaborative Knowledge Inquiry	4	Provide new insights and professional expertise to further develop the application of knowledge artefacts and spark deeper community discussions.
Improving and Transforming Knowledge	5	Synthesize ideas and alternative perspectives to develop new theories or improve collective knowledge within the network.

APPENDIX L: Contact Summary Sheet

Name of Participant:

Question	Knowledge Building Principles	Knowledge Building Inhibitors	Notes
1. Briefly explain how you acquired knowledge about your profession before this research project?	o Real Ideas and Authentic Problems o Improvable Ideas o Idea Diversity o Rise Above and Scaffolding of Ideas o Epistemic Agency o Knowledge Community and Collective Responsibility o Knowledge Building Discourse o Constructive Uses of Authoritative Sources o Embedded Transformative Assessment	o Connective Efficacy o Group Identification o Knowledge Classification and Codification o Knowledge Contribution o Knowledge Self Efficacy o Offline Interactions o Personal Identify Verification o Professional Evaluation Apprehension o System Quality	
2. As you began to use Knowledge Net more frequently have you found that you seek different sources of knowledge or use knowledge in a different way?	o Real Ideas and Authentic Problems o Improvable Ideas o Idea Diversity o Rise Above and Scaffolding of Ideas o Epistemic Agency o Knowledge Community and Collective Responsibility o Knowledge Building Discourse o Constructive Uses of Authoritative Sources o Embedded Transformative Assessment	o Connective Efficacy o Group Identification o Knowledge Classification and Codification o Knowledge Contribution o Knowledge Self Efficacy o Offline Interactions o Personal Identify Verification o Professional Evaluation Apprehension o System Quality	
3. Can you explain what you believe is involved in the process of effective shared knowledge building?	o Real Ideas and Authentic Problems o Improvable Ideas o Idea Diversity o Rise Above and Scaffolding of Ideas o Epistemic Agency o Knowledge Community and Collective Responsibility o Knowledge Building Discourse o Constructive Uses of Authoritative Sources o Embedded Transformative Assessment	o Connective Efficacy o Group Identification o Knowledge Classification and Codification o Knowledge Contribution o Knowledge Self Efficacy o Offline Interactions o Personal Identify Verification o Professional Evaluation Apprehension o System Quality	

Question	Knowledge Building Principles	Knowledge Building Inhibitors	Notes
4. What have you learned about yourself as a knowledge builder as you have worked within Knowledge Net?	○ Real Ideas and Authentic Problems ○ Improvable Ideas ○ Idea Diversity ○ Rise Above and Scaffolding of Ideas ○ Epistemic Agency ○ Knowledge Community and Collective Responsibility ○ Knowledge Building Discourse ○ Constructive Uses of Authoritative Sources ○ Embedded Transformative Assessment	○ Connective Efficacy ○ Group Identification ○ Knowledge Classification and Codification ○ Knowledge Contribution ○ Knowledge Self Efficacy ○ Offline Interactions ○ Personal Identify Verification ○ Professional Evaluation Apprehension ○ System Quality	
5. What are some challenges you have encountered as you have shared and created knowledge with other participants?	○ Real Ideas and Authentic Problems ○ Improvable Ideas ○ Idea Diversity ○ Rise Above and Scaffolding of Ideas ○ Epistemic Agency ○ Knowledge Community and Collective Responsibility ○ Knowledge Building Discourse ○ Constructive Uses of Authoritative Sources ○ Embedded Transformative Assessment	○ Connective Efficacy ○ Group Identification ○ Knowledge Classification and Codification ○ Knowledge Contribution ○ Knowledge Self Efficacy ○ Offline Interactions ○ Personal Identify Verification ○ Professional Evaluation Apprehension ○ System Quality	
6. What do you believe is the most important characteristic of successful shared knowledge creation?	○ Real Ideas and Authentic Problems ○ Improvable Ideas ○ Idea Diversity ○ Rise Above and Scaffolding of Ideas ○ Epistemic Agency ○ Knowledge Community and Collective Responsibility ○ Knowledge Building Discourse ○ Constructive Uses of Authoritative Sources ○ Embedded Transformative Assessment	○ Connective Efficacy ○ Group Identification ○ Knowledge Classification and Codification ○ Knowledge Contribution ○ Knowledge Self Efficacy ○ Offline Interactions ○ Personal Identify Verification ○ Professional Evaluation Apprehension ○ System Quality	

Question	Knowledge Building Principles	Knowledge Building Inhibitors	Notes
7. How did your experience with Knowledge Net impact you as an educator?	○ Real Ideas and Authentic Problems ○ Improvable Ideas ○ Idea Diversity ○ Rise Above and Scaffolding of Ideas ○ Epistemic Agency ○ Knowledge Community and Collective Responsibility ○ Knowledge Building Discourse ○ Constructive Uses of Authoritative Sources ○ Embedded Transformative Assessment	○ Connective Efficacy ○ Group Identification ○ Knowledge Classification and Codification ○ Knowledge Contribution ○ Knowledge Self Efficacy ○ Offline Interactions ○ Personal Identify Verification ○ Professional Evaluation Apprehension ○ System Quality	
8. Can you provide an example of a knowledge-building experience that you had during this research study?	○ Real Ideas and Authentic Problems ○ Improvable Ideas ○ Idea Diversity ○ Rise Above and Scaffolding of Ideas ○ Epistemic Agency ○ Knowledge Community and Collective Responsibility ○ Knowledge Building Discourse ○ Constructive Uses of Authoritative Sources ○ Embedded Transformative Assessment	○ Connective Efficacy ○ Group Identification ○ Knowledge Classification and Codification ○ Knowledge Contribution ○ Knowledge Self Efficacy ○ Offline Interactions ○ Personal Identify Verification ○ Professional Evaluation Apprehension ○ System Quality	
9. How do you feel professional learning leads and divisional leaders can best support shared knowledge creation within the school district?	○ Real Ideas and Authentic Problems ○ Improvable Ideas ○ Idea Diversity ○ Rise Above and Scaffolding of Ideas ○ Epistemic Agency ○ Knowledge Community and Collective Responsibility ○ Knowledge Building Discourse ○ Constructive Uses of Authoritative Sources ○ Embedded Transformative Assessment	○ Connective Efficacy ○ Group Identification ○ Knowledge Classification and Codification ○ Knowledge Contribution ○ Knowledge Self Efficacy ○ Offline Interactions ○ Personal Identify Verification ○ Professional Evaluation Apprehension ○ System Quality	

Question	Knowledge Building Principles	Knowledge Building Inhibitors	Notes
10. Do you feel there is a clear vision for the creation and sharing of knowledge by teachers within the school division?	○ Real Ideas and Authentic Problems ○ Improvable Ideas ○ Idea Diversity ○ Rise Above and Scaffolding of Ideas ○ Epistemic Agency ○ Knowledge Community and Collective Responsibility ○ Knowledge Building Discourse ○ Constructive Uses of Authoritative Sources ○ Embedded Transformative Assessment	○ Connective Efficacy ○ Group Identification ○ Knowledge Classification and Codification ○ Knowledge Contribution ○ Knowledge Self Efficacy ○ Offline Interactions ○ Personal Identify Verification ○ Professional Evaluation Apprehension ○ System Quality	