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EDUCATING FOR THE KNOWLEDGE AGE: A COLLECTIVE CASE STUDY OF TEACHERS' BELIEFS IN A PROBLEM BASED LEARNING ENVIRONMENT

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A COLLECTIVE CASE STUDY OF TEACHERS' BELIEFS IN A PROBLEM BASED LEARNING ENVIRONMENT

BY

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DISSERTATION

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Abstract

There is a growing trend in the business literature; education is not preparing students for the Knowledge Age. The literature further states the foundation of a successful Knowledge Economy and the production of its knowledge workers is education. Considering that the school system is a foundation for learning, it is a startling revelation that education reform has not focused more explicitly on knowledge work. If we expect to be successful in the Knowledge Age, a new conception of knowledge and learning is necessary, and will aid in the development of new knowledge workers. This further necessitates a more in depth understanding of what epistemological beliefs, and corresponding pedagogical practices would foster students who can work successfully in the Knowledge Age.

This collective case study explored four teachers' understanding of knowledge and pedagogy using an adaptation (Keefer & Ruffus, 2004) of the Approach to Knowledge Scheme (ATKS*)* (Bereiter & Scardamalia, 1998) and the Principles of Knowledge Building (Scardamalia, 2003). Data collected from the study of two English/Communication Arts teachers and two Science teachers included unit plans, pre-observation interviews, observations and post-observation interviews. Thematic analysis was used to examine teachers' epistemological beliefs and pedagogical practices, and revealed major themes by both sets of teachers. These themes were useful in understanding how the ideas of the Knowledge Age and knowledge workers can be implemented in schools. Content Analysis demonstrated the ATKS was a useful tool to use with teachers, with modifications. By using this theory and scheme it was possible to see how these teachers' views impact what knowledge they found valuable; in so doing, provided an opportunity to see how knowledge work could be translated into education.

To my family

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Chapter 1

Introduction

In a speech given at the National Education Summit on High Schools, Bill Gates (2005) declared, "… America's high schools are obsolete…training the workforce of tomorrow with the high schools of today is like trying to teach kids about today's computers on a 50-year-old mainframe. It's the wrong tool for the times."

His sentiments echo a growing trend in the business world: education is not preparing students to be productive members of the new Knowledge Age. As the manual labor market decreases and the knowledge-based economy grows, employers are shifting their focus and hiring workers who are familiar with using and improving knowledge. These new workers, knowledge workers, now make up more than one-third of the workforce, and the number is steadily rising (Drucker, 1994). Clearly, K-12 schools must begin preparing students to be the knowledge workers of the future.

While there is no consistent definition for knowledge workers, there are threads that run throughout the literature. Drucker (1959) first suggested that a knowledge worker improves and works with knowledge. Knowledge workers are also: flexible, highly educated, independent, quick to learn, operate from a specialized knowledge base, and are able to work cooperatively with various specialty groups (Garrick & Clegg, 2000; Pyoria, 2005; Rodriguez, 2006; Scarbrough, 1999; Syed, 1998).

Some researchers assert that education is the cornerstone that will create a smooth transition to the Knowledge Age (e.g., Griffith, 2005; King, 2006; Reich, 2005). Yet, other researchers have suggested that schooling and/or the structure of schools needs to

change to prepare students to become knowledge workers (e.g., Duffy, 1997, 2000; Duffy & Blick, 1998; Frueling, Kerin, & Sebastian, 1997; Goodyear, 2007; Lakomski, 2007; Leddick & Gharajedaghi, 2001; Peel & McCary, 1997; Sasse, Schwering, & Dochterman, 2008; Tan, Chong, & Wong, 2007; Tucker, 1988). Paavola & Hakkarainen (2005) have proposed a shift in educators' epistemological beliefs is both critical and necessary if education is going to meet the needs of students in the Knowledge Age. Since success in the Knowledge Age is dependent on education, it is surprising that educational literature accounts for less than 11% of articles published on the topic, as a search of ERIC, EDPsych and Educational Full Text in 2007 demonstrated**.** If, education is in fact the key factor in successfully preparing students to be knowledge workers, educators' understanding of knowledge and their awareness of its importance is a key component in that preparation.

Business literature repeatedly states we are in a new age and we need a new conception of knowledge, but it only offers a commonsense epistemology for knowledge work, based on observation and economic trends. Do the necessary changes to accommodate for the Knowledge Age stem from something deeper than the commonsense epistemology would lead one to believe? The business commonsense understanding of the Knowledge Age is not sufficient because a change to the Knowledge Age not only requires us to rethink how we work, and what jobs are desirable, but it also causes us to rethink our understanding of knowledge, learning, and the mind. Yes, the transition from the Industrial Age to the Knowledge Age has caused us to rethink desirable characteristics of employees, how they work, and even what they sell. Should it also force us to reconsider our theoretical understanding underlying those changes? Researchers

(Drucker, 1994; Griffith, 2005; King, 2006; Reich, 2005) believe a new conception of knowledge is necessary, and that change must come from within education. If a different kind of worker is required to achieve success in the Knowledge Age, and it is the job of education to prepare them, the following question arises: What are educators' views of knowledge?

Historically, education's dominant view of knowledge, the teacher, and learner, has fallen in line with the conception of knowledge as, "the sum of what is known; a body of truth…acquired by humankind" (Merriam Webster, n.d., para. 4) and a "justified belief" (Concise Oxford American Dictionary, 2006, p. 492). In this model it is a teacher's job to communicate that "justified belief" to students, who are then expected to memorize and regurgitate. The purpose of education, from this perspective, is for the teacher to get correct factual information into the heads of students. When a student has actually learned something, there will be an accurate connection between the factual information the teacher has presented about the physical world, and what is in the student's mind. Even though this standard model in education has been questioned in recent years, (Bransford, Brown, and Cocking, 2000; Bruner, 1996) it still permeates the culture of education. If the standard model in education aligns with the Industrial Age and if, as the literature suggests, there needs to be a fundamental shift in our understanding of knowledge to compete in the Knowledge Age, does education have an epistemology adequate for the Knowledge Age? Are educators prepared to teach students for the Knowledge Age?

The Institute for Knowledge Innovation and Technology (IKIT), headed by Carl Bereiter and Marlene Scardamalia, propose Knowledge Building/Deep Constructivism, as

a useful theory for the Knowledge Age. Knowledge Building refers to a cyclical process of creating and improving ideas, through a process of inquiry and debate. Improvable ideas can be demonstrated on a spectrum of complexity, from first graders proposing ideas about why leaves change colors in the fall, to car manufacturers and engineers developing green technology for automobiles (Scardamalia & Bereiter, 2003). Improvement of an idea or object is the common result in both cases.

The traditional classroom expects to "fill" the students' minds with knowledge, but a Knowledge Building classroom expects teachers to both design environments where students explore authentic problems, and guide them along the process of inquiry. Teachers may have an idea of what they hope students will learn, but the students have control over objectives, research strategies, and proposed solutions. Because of this model's complexity, students work in groups to research a problem, propose ideas to solve the problem, critique those ideas, and agree upon a solution.

A comparison between a traditional and a Knowledge Building classroom can be made using a middle school Science class covering glades as an example. In the traditional classroom a teacher might lecture on different aspects of the glades, flora, fauna, and compare similarities and differences to other woodland areas. This could be interspersed with various activities, and perhaps a field trip. The summation of the unit is a formal assessment, usually a test, where the students reiterate their knowledge (facts) of glades.

A Knowledge Building classroom allows students to own their problem and solution. They are presented with a real (authentic) problem such as deforestation of valuable glade wildlife, and are asked to make an informed decision to "solve" the

problem. The students, in groups, are given the choice of exploring particular aspects of the problem. They might choose to explore the deforestation's impact on soil erosion, animal life or over-grazing cattle. After agreeing on a focus to research, they might seek out experts (ecologists) to help answer questions and guide their research process. Students critique and challenge each other throughout the process until a final course of action is found. One group might propose a hands-on action plan to re-plant various flora to deter cattle. This plan would be based in facts gathered from their research. Another group might propose creating educational brochures, using facts from their research, to be placed at the beginning of trails in glade conservation parks. The purpose of the brochures would be to educate the people using the trail on how to best minimize their impact on the glade and even how to improve the area during their visit. Whether planting new flora or producing brochures, students would be translating factual knowledge and using it improve a situation and solve a problem. Teaching for the Knowledge Age, then, involves hands-on, active learning, choice of what knowledge to seek and from what source, and a team approach.

To help aid educators teach students for the Knowledge Age, Bereiter and Scardamalia (1998) created an Approach to Knowledge Scheme. This scheme offers seven progressive levels of approach to knowledge. The levels range from level 1- knowledge as listable mental content, to level 7- knowledge as improvable personal artifacts. These seven levels and will be further detailed and explored later in Chapter 2. Bereiter and Scardamalia (1998) believe the progression through these seven levels represent educational objectives, "of particular significance to a knowledge society" (p. 5).

Our old understanding of knowledge, learning and the mind, aligned coherently

with the Industrial Age. But if we now expect employees to be more than assembly line workers, and if a business' success or failure rides on its employees' ability to think abstractly, while applying and improving knowledge, there needs to be an understanding of knowledge that better aligns with the needs of the Knowledge Age. So what does this new conception of knowledge look like? If we rethink our understandings about the workplace, what would our expectations of the new knowledge-based workforce be? How are we to prepare the intellectually skilled workforce necessary for the Knowledge Age?

Purpose of the Study

The purpose of this study is to further investigate what epistemological beliefs and pedagogical practices of teachers would be helpful in preparing students for the Knowledge Age. It was anticipated that a collective case study would illuminate how and/or if the Knowledge Building (Scardamalia and Bereiter, 2003) and the Approach to Knowledge Scheme (Bereiter & Scardamalia, 1998; Keefer & Ruffus, 2004; Ruffus et al., 2007) can be applied to teachers' views of knowledge, pedagogy and curriculum in a Problem Based Learning (PBL) environment to categorize teachers' epistemological beliefs. Furthering this discussion may facilitate the development of a conception of education consistent with the needs of the Knowledge Age.

Bereiter and Scardamalia have begun the discussion, concerning students, with their theory of Knowledge Building and Approach to Knowledge Scheme, but what do we know about teacher beliefs and their role in educating students for the knowledge age?

Guiding Research Questions

Based on the review of relevant literature, this collective case study is designed around the following guiding research questions:

1.) What are teachers' epistemological beliefs and pedagogical practices in a Problem Based Learning (PBL) setting?

2.) Is the Approach to Knowledge Scheme an applicable tool to use with teachers and how can it be further modified to better reflect the ideas of the Knowledge Age?

Delimitations

The participants in this study were all from one Midwestern public school district located in a metropolitan area. The teachers already practiced problem based learning**.**

Definitions of Terms

The present study used several terms that are crucial to this examination and were intended to be used with very specific meanings. Following are the terms and definitions to be used for the duration of this paper.

1.) Knowledge: A range of understanding of knowledge as physical objects to subjective mental events to autonomous artifacts

2.) Knowledge Age: Era of socioeconomic development characterized by the majority of workers creating and improving knowledge.

3.) Knowledge Worker: Someone who works primarily with knowledge and applies it to create a new product or output (Drucker, 1959; 1994). Several characteristics guided by the literature also helped define characteristics of a knowledge worker: highly educated people, working in a relatively unstructured environment, whose main input and output is knowledge (Pyoria, 2005; Scarbrough, 1999). This category also includes people who convey directly what they know and, "…transmit information indirectly, and through a large supporting cast of knowledge-producing employees" (Rubin & Huber,

1998, p.91-92). For the purpose of this study this category will only include educators.

4.) Knowledge Objectification: Using knowledge as an autonomous artifact that is improvable (Bereiter & Scardamalia, 1998).

Significance of the Study

Even though knowledge work is an accepted practice in business, there is little mention of it explicitly in education, with the exception of the influential work of Carl Bereiter, Marlene Scardamalia and their colleagues at IKIT (Bereiter, 2002a; Scardamalia, 2002; Scardamalia & Bereiter, 2003; Tan, Hung, & Scardamalia, 2006). This is a startling revelation. If the school system is a foundation for learning, and the importance of education for a successful transition to the Knowledge Age is needed (e.g., Griffith, 2005; King, 2006; Reich, 2005), much more attention must be focused on how teachers prepare students for this approaching Knowledge Age. This is even more surprising given that knowledge work is an accepted practice in business.

If we expect to be competitive and prepare our students to be productive workers and citizens in the 21st century, a new conception of knowledge needs to be considered. When one thinks that teachers, prepare future workers for success in the Knowledge Age, the need to look at teachers' approaches to knowledge becomes important**.** Bereiter and Scardamalia's theory of Knowledge Building (2003) and Approach to Knowledge Scheme (1998) are first steps in creating a common discourse for knowledge work in education. Because their research is based solely on a student's ability to use and improve knowledge, more work needs to be done to explore teachers' beliefs.

Therefore, it is the aim of this study to explore teachers' epistemological beliefs and pedagogical practices as well as the usefulness of the Approach to Knowledge Scheme. If students are expected to be improvers of knowledge, do the beliefs and practices of teachers encourage such a result? How do teachers lead students to be flexible, independent, and abstract thinkers who view knowledge as evolving and improvable**?** Through an in depth case study of four teachers, the present study has the potential to add to education's understanding of how to educate students for the in the new Knowledge Age. It is hoped that interviews, observations, and unit plans of these four teachers will further establish a theoretical framework that will help teachers prepare students for the Knowledge Age.

Chapter 2

Review of Related Literature

At the turn of the 20th century, after high school graduation, students expected to obtain stable jobs in factories and plants. However, with the improvement of technology, and the invention of computers and robots, industrial jobs are becoming less available. Such jobs are usually lower wage jobs and generally less desirable to the emerging work force (Reich, 2005; Schement & Curtis 1998). Businesses are now focusing on using knowledge and the production of information to become a more efficient, advanced society (Pyoria, 2005). "As we move from the Industrial Age into the Information Age, knowledge is becoming a key driver for the competitive success of firms and even nations" (Martinez-Torres, 2006, p. 617).

Emergence of the Knowledge Age

Expectations are changing and employers want workers who are familiar with using and improving knowledge (Bell, 1973; Drucker, 1959; Machlup, 1998; Pyoria, 2005). With machines and computers controlling the manual labor market, knowledge workers, a term first popularized by economist Peter Drucker (1959), now comprise more than one third of the labor force, and the numbers are increasing (Drucker, 1994). Almost 30 years after Drucker's (1959) initial assertion, there is a lack of qualified knowledge workers (Louis Harris & Associates, Inc., 1987) and this shortage continues to exist (Meisinger, 2006).

If we are changing to a knowledge-based economy and different kind of worker is

necessary to be successful then the question becomes: What are characteristics of the worker in the Knowledge Age and what is the workers optimal environment?

Knowledge worker. With the documented importance of, and increase in this population the question still remains, what exactly is a knowledge worker? In a recent dissertation, Rodriguez (2006) found only 71 out of 442 articles that discussed knowledge work provided definitions of knowledge workers. In those 71 articles the definitions were not consistent. Drucker's (1959, 1994) original classification articulated a knowledge worker as someone who works primarily with knowledge and applies it to create a new product or output. Since Drucker's original definition in 1959, researchers have refined and expanded the understanding of a knowledge worker (Machlup, 1998; Pyoria, 2005; Rubin & Huber, 1998; Scarbrough, 1999). There are basic themes that run throughout the current research, but there is no universal definition. Knowledge workers are highly educated people, working in a relatively unstructured environment, who have very specialized knowledge and whose main input and output is knowledge (Pyoria, 2005; Rodriguez, 2006; Scarbrough, 1999). They are also expected to be flexible, independent, learn quickly, and work well with other departments and disciplines to create the knowledge product (Garrick & Clegg, 2000; Rodriquez, 2006; Syed, 1998).

Machlup (1998) and Rubin and Huber (1998) further subdivide knowledge workers into *knowledge producers* and *knowledge communicators*. Knowledge producers create and apply knowledge and include scientists and doctors. Knowledge communicators convey directly what they know but also, "…transmit information indirectly, and through a large supporting cast of knowledge-producing employees" (Rubin & Huber, 1998, p. 91-92). Knowledge communicators work with knowledge, primarily through discourse, on a

regular basis. This category includes educators, managers, and some physicians. The classification of knowledge communicators enables the inclusion of an additional group of workers who, while not creating knowledge on a regular basis, work with knowledge, transmit knowledge, and facilitate knowledge creation.

Although the idea of knowledge work and knowledge workers has been around for over 40 years there is still no consistent definition of the term knowledge work. There is no consistent understanding of who knowledge workers are. To add to the confusion, knowledge workers are generally classified by what they are not, that is manual labor workers (Rodriquez, 2006). When someone is not the more clearly understood manual laborer they are, by default, a knowledge worker, but there is not a consist definition of what that is. Accepting the importance of a knowledge worker without clearly understanding what a knowledge worker is can be problematic since a consistent definition moves towards standardization. One obstacle is the single classification, knowledge worker. This term incorporates such a diverse population that it is difficult to agree upon one definition that accurately describes the various kinds of knowledge workers. The ambiguity inherent in all the definitions and the diverse population of knowledge workers has led some to re-categorize knowledge workers. Machlup (1998) and Rubin and Huber (1998) attempt to clarify the definition of knowledge workers by creating subcategories: knowledge producer and knowledge communicator**.** While it is probably necessary to delineate different types of knowledge workers in order to clarify the groups and agree on a universal definition, the subcategories require further clarification and could lead to the same myriad of misunderstandings. Even as there is no uniform definition, there are consistent characteristics. One such characteristic includes

the need for diverse set of specialized knowledge, to create a new knowledge product. The necessity to draw on other peoples' specialties in order to successfully create new knowledge products has spawned a popular area of research in the business literature called knowledge work teams.

Knowledge Work Teams. Because knowledge work is far too complex and requires such a variety of specializations Lewis (2004) and Shani (2000) suggest that knowledge workers must be placed in teams if they (the workers) expect to succeed. If each team member possesses specialty knowledge that cannot create the product alone, they must work on the project as a group**.** Finding knowledge sharing and collaboration a necessity**,** recent research focuses on the importance of knowledge creation teams, knowledge communities and the promotion of effective knowledge sharing within the team (Garrick & Clegg, 2000; Lengnick-Hall & Lengnick-Hall, 2006; Lewis, 2004; Lindkvist, 2005; Martinez-torres, 2006; Norris et al., 2003; Scott, 2005; Sawng et al, 2006; Shani, 2000; Syned, 1998). Knowledge work teams are now so widely accepted in the business literature that recent articles discuss not why they are important, but rather how to create successful ones.

If knowledge sharing and creation are best executed in a group structure, how should this group be structured? Sawng et. al (2006) offer guidelines for creating knowledge work groups. After administering 300 self-report questionnaires to 58 research and development firms they found that different compositions of workers were necessary depending on the task objective. Knowledge sharing, a vital part of the process, is at its highest and most effective level when the group or company is larger and has a high amount of diversity. Conversely, knowledge creation is most prevalent with small cohesive groups. Commitment to the group and the project

increased the speed and effectiveness of both knowledge creation and knowledge sharing. Depending on the task objective, should employers consider different structures for success? If employees are working in groups how do the dynamics work? How do a group of equals from different knowledge disciplines find a cohesive style?

Transactive Memory Systems-Embedded Team Knowledge. Embedded team knowledge of group functioning was first theorized by Wegner (1987) to explain how people in close relationships organize and remember communal information. He termed this phenomenon a Transactive Memory System (TMS). A TMS is comprised of individual memory, external memory, and Transactive Memory and was first used to try to explain the complexities of how the group mind interacted with the individual mind. TMS relies on a group memory and a group mind and represents the capacity to remember who knows what. TMS helps workers understand, "…issues of knowledge utilization by explaining how team members develop, share and efficiently integrate their expertise…it is a form of knowledge that is embedded in team members and in a team's structure and processes" (Lewis, 2004, p. 1519). Negotiating how to interact, who to contact for what information, the frequency, style, and format of meetings permits the members to work together more smoothly.

Rooted in the idea of TMS is the effectiveness of group process and structure as a form of knowledge that becomes very important to reproduce. Since each member has his/her own expertise in the group, it can lack leadership and formal structure. Knowledge work tasks also tend to be ill-structured problems so, if the TMS is to be most effective, deciding how the group members will operate prior to starting the project might ease this complex task. Lewis (2004) believes that the implementation process of the TMS before

the beginning of projects helps to expedite group members' strengths, knowledge sharing, and group structure. According to Lewis a fully developed TMS, appears to help teams, "…fully utilize members' expertise and realize the value of embedded team knowledge, implying that TMSs represent an important point of leverage for team-based organizations" (Lewis, 2004, p. 1519). The idea does appear to have useful implications considering businesses' insistence that teams and group knowledge are necessities. Nevertheless, with little research and only one empirical study by Lewis (2004), it must be considered with caution.

The business literature suggests that the move into the Knowledge Age requires a different kind of worker, in a different kind of environment, and the suggested changes do not stop at the office door. The Knowledge Age has also transformed the commodity, the sellable product of businesses. It is easy to understand the output of manual labor workers, but the output of knowledge is not so obvious. Although it is not mentioned extensively in the literature, intellectual capital or human capital is the sellable product of the 21st century**.** It is a shrewd move on the part of business to tie knowledge to product and thereby make information sellable and tangible (Garrick & Clegg, 2000). Intellectual capital is defined as, "…what people know, the skills they have honed, the observations that they can interpret, and the situations in which they can act effectively" (Lengnick-Hall & Lengnick-Hall, 2006 p. 186). It can also include the ability to deal with abstract ideas (Pyoria 2005).

Although it is not directly stated, the assumption here is that the marketability of a company and its products reaches beyond the factory floor and into the hands of its employees. This is an interesting difference from the Industrial Age where the employers

owned the tools and resources of production and workers were simply the manual labor behind the product.

The preceding paragraphs discuss the change from the Industrial Age to the Knowledge Age, and suggests that the traditional roles of workers will be different as we move out of a predominate age of employees producing goods, to an age where employees are expected to use and improve knowledge. The change is already occurring in businesses and the difference from a traditional workplace is substantial. Questions that must be answered are – What are the implications for individual workers? What do these new workers really *do*? What does the new workplace look like?

An assembly line worker often does repetitious tasks without understanding or working on any other component of the product. In the Industrial Age, the goal of quick and efficient mass production of objects was met by such an operation. The role of the industrial worker was to show up on time, perform their assigned task and return the next day to perform the same tasks all over again in exactly the same manner. In today's market, a knowledge worker is expected to actively participate in finding ways to improve the product, not just repeat their assigned task. The result of this work could be sustainable automobile fuel technology, renewable energy resources, or even new teaching strategies.

So, what would a knowledge worker do during the workday? First, knowledge workers are set to solve a problem. An example of a problem a knowledge worker would address is the following. Executives for a car manufacturer may notice the increase gas prices and increased data on the harmful effects of gasoline on the environment. This may prompt them to assemble a group of knowledge workers to go about solving the problem.

The problem statement might be -"How do we make a car that is more fuel efficient and/or less harmful to the environment without sacrificing a price or style?" In order to address the many facets of this problem the company would need to assemble a team of "experts" who have significant knowledge in areas relevant to the problem. The team might include, financial experts, environmental scientists, chemists, engineers, and market analysts**.** In this team of experts, the knowledge the chemist brings to the table is just a valuable to solve the problem as the knowledge of the engineer or financial expert. This group of equals must figure out an effective way to work together, and to bring together various and extensive knowledge of their specialties areas to create a more fuel efficient, environmentally friendly car.

By looking at literature and research about the Knowledge Age and knowledge workers, it is becoming clear that the workforce is dramatically changing from the Industrial Age. If the Knowledge Age is requiring us to rethink our expectations of our employees, employers and our schools we should also be thinking about a new theoretical understanding to align with these changes?

Education's epistemological beliefs: Is education stuck in the Industrial Age?

Historically, education's standard view of knowledge, correlated with the idea that knowledge is a body of truth acquired by humankind and a justified belief. If the goal, in this model, is to fill students' minds with a body of "true" knowledge, how do we determine what is true knowledge or a justified belief? This model would suggest that, if someone possesses true knowledge, there is a correlation between what is in the physical world, physical objects, and what exists in the person's mind, subjective mental objects. If what is "in your mind" tells the same story as what is "in the world" one would say you

have a true understanding of the subject. During the manufacturing age, Bloom (1956) published a detailed hierarchical classification of learning. In this taxonomy, Bloom relegated knowledge to the first level**:** discrete facts. In this category, students are expected to recall, recognize or define information. Bloom's model displays the same explanation of knowledge as the standard model's definitions. Students are only required to remember or describe information and that is considered having knowledge. The highest level in the taxonomy is evaluation where students are expected to compare/contrast, critique, and interpret prior knowledge, based on their personal judgment. At all levels, from the lowest to the highest levels, Bloom's taxonomy aligns with the definition of knowledge as a finite body of truth and a justified belief. Even though this view has been consistently debunked by education and psychology researchers (Bransford, Brown, and Cocking, 2000; Bruner, 1996), it still dominates teaching practices today. Furthermore, it does not offer a conception of knowledge that is complex enough to address the changing needs of the Knowledge Age. It is proposed that the standard model in education is not sufficient for the Knowledge Age. The question then becomes "what are other paradigms in education that can begin to address the challenges presented by the Knowledge Age and help form a more modern view of knowledge and the role of knowledge in education?"

Socio-historical perspective. Socio-historical theory offers a more progressive theoretical framework that could help elucidate the phenomenon understood by our commonsense standard beliefs about knowledge and knowledge work. This theory states that learning is not something possessed by the individual mind and then shared with society, but that learning first takes place within society and then is internalized by an

individual. In other words inter-mental understanding precedes intra-mental understanding (Cole & Wertsch, 1996; Vygotsky, 1978). It becomes important to look at not only the individual but also how understanding is developed within social groups, larger systems and materials. Vygotsky (1978) argued the process of internalization from the external (culture) to the individual, is mediated by tools and signs, which range from language, to counting, art, math, and mnemonic techniques.

These "external representations", tools, or cognitive artifacts, do not just increase one's memory, they can transform a task, change how information is processed, (Perry, 2003) and can actually contain intelligence (Pea, 1993). They are culturally oriented and are a way for humans to interact with the environment. Signs/tools are the instrument of thinking and become auxiliary ways of solving problems that are too complex for any one individual to solve. As a result, thinking and learning become a transaction between culturally structured environments, the mediation of artifacts, tools, and the individual mind. Learning is in a sense, tools and signs in activity. The mind is no longer solely inside the head, but higher mental functions like knowledge work, "…are transactions that include the biological individual, the culturally mediational artifacts, and the culturally structured social and natural environments of which persons are a part" (Cole & Wertsch, 1996 p. 253).

Distributed cognition further develops Vygotsky's ideas and proposes that knowledge, the mind, and cognition do not simply include tools and cultures to derive meaning, but are distributed across those tools and cultures (Salomon, 1993). Distributed intelligence, which sees intelligence and knowledge as something that is socially constructed between individuals and the tools they use in their environment (Pea, 1993),

also helps us understand some of the issues in the Knowledge Age. "When I say that intelligence is distributed, I mean that the resources that shape and enable activity are distributed in configuration across people, environments and situations" (Pea, 1993, p. 50). The interaction between individuals, mediating tools and socially created understanding can create a depth of knowledge that is impossible for one person to achieve. If learners understand and create distributed intelligence as a tool, rather than seeing knowledge and intelligence as a substance, it could change how they utilize resources in the world to direct activity (Pea, 1993).

Situated Cognition. If one accepts the proposition that cognition is distributed across people, their environments and tools, then one must also consider the argument that cognition is situated in these relationships and networks (Brown, Collins & Duguid, 1989a). Proponents of situated cognition believe that if individuals need to interact with the environment through tools and with other people, then learning must be situated within those particular contexts. In other words, "Cognition must be viewed as an integral part of the physical, social and cultural context in which it belongs" (Derry, 1992 p. 416).

How do situated cognitive theorists define knowledge? "Knowledge is an emergent phenomenon of community of practice … it is actively instructed, supported, communicated … transformed, extended and examined with that community. In sum, knowledge is socially 'negotiated' with a community" (Derry, 1992, p. 416). In situated cognition, knowledge and the situation cannot be separated from location. If knowledge is situated and developed within a community then it is not abstract or independent of that community. Instead, Brown, Collins, and Duguid (1989a) suggested we think of conceptual knowledge as a set of tools. Therefore, if it is a set of tools, our

understanding of tools must be applied to it. Recognizing conceptual knowledge as a tool implies it can only truly be understood through use and the user must adopt the communities' belief system that created the tool in order to use it.

If we understand from the situated perspective that knowledge cannot be separated from the environment, how does that impact our views of learning? Learning is fundamentally situated and is the combination of activity, concept and culture (Brown, Collins, & Duguid, 1989a) or participation in social practice (Greeno, 1997). A student who is in a particular environment will observe, interact, and adapt to that environment, in essence the student learns.

Apprenticeship Learning. Given that situated cognitive theorists believe knowledge and learning occurs through participation in social practice, a few questions arise. How should learning environments and the classroom be best structured? If learning must take place in a community of practice, is classroom learning obsolete? Given their understanding of knowledge and learning, researchers first looked to traditional apprenticeship as a model for the classroom (Lave & Wenger, 1991). As Lave and Wenger (1991) point out, "In the United States today much learning occurs in the form of some sort of apprenticeship, especially wherever high levels of knowledge… are in demand" (p. 63). In a traditional apprenticeship the learner is placed in the environment in which they will be working, and learns their skills step by step, through observation and practice. The learner is put in the community of practice thereby allowing for a contextualization and interaction between the environment, student, expert and tools. As previously stated, in this paradigm that is a necessary component for learning. Traditional apprenticeships put the student in direct contact with the expert or teacher allowing the

student access to the expert's "processes". It makes the skills and the process, "…readily available to both students and teacher for observation, comment, refinement and correction" (Collins, Brown & Newman, 1989, p. 457).

However, the environment in which traditional apprenticeship evolved is different from the needs of the modern school and modern students. Therefore the concept needed to be reinvented for the modern day student and has been re-conceptualized as cognitive apprenticeships. A cognitive apprenticeship, which is strongly connected to the concept of knowledge as a tool, is a potentially necessary update for the modern educational system because it allows for the externalization not of the craft process but of the thinking process. By bringing thinking to the surface, it allows the students to "see" how the experts or teachers go through the process of thinking. It also allows for knowledge to be, "…learned in terms of their uses in a variety of contexts, encouraging both a deeper understanding of the meaning of the concepts and facts themselves…" (Collins Brown, & Newman, 1989, p. 457). Cognitive apprenticeship does not assume that all students are going to become professional mathematicians or historians. Rather, it assumes students need more than isolated knowledge and examples to be enculturated into the community of practice so as to understand a subject (Brown, Collins & Duguid, 1989a). Through authentic activities, cognitive apprenticeship allows exposure to the tools in the context of the domain, to fully understand their use.

Critiques of Situated Cognition. While situated cognition has had a transformative impact on our views of education and learning, there are important critiques to note**.** In her article "Less Chartered Waters"**,** Palincsar (1989) presented an evaluation of the weaknesses of situated cognition. One area of concern is the idea that learning should take place in a community of practice. Palincsar argued we rightly have different

expectations of students and practitioners and it is unfair to assume the two classes are comparable**.** It would be almost impossible to immerse students in all of the communities of practice in all subject matters currently addressed in our schools. Another point of contention is with the idea of a shared culture. Many disciplines and communities have diverse and conflicting views of knowledge. Therefore there may be much less of a consistent shared culture than Brown, Collins and Duguid (1989a) assumed. Further, Palincsar questions if a shared culture is even advantageous as progression in a discipline often comes from conflicting views. If students are to be immersed in the community of practice, which perspective would the school take and how would they choose from multiple or conflicting views?

Another area of conflict for Palincsar (1989) is the claim that knowledge is a tool and should be treated accordingly. She points to an example of Amazonian travelers who left modern tools for the primitive Amazonian tribe, the Yanomamo. While some tools were not used, others were seamlessly adapted to the Yanomamo culture without knowledge of, or adaptation of, the tools' originating culture. She argues that this example demonstrates that, if the knowledge inherent in the tool is dynamic, it should not require an explanation for use or an adaptation of cultural viewpoints. In a response to Palincsar's critique, Brown, Collins and Duguid (1989b) argue that yes, the Yanomamo used some of the tools left by the Amazonian travelers successfully, but for reasons different than those proposed by Palincsar. Instead, they counter that the Yanomamo have similar tools and were able to substitute the needed understanding from their own culture. Bereiter (1997) also offers criticism of knowledge as a tool. For him, the account of knowledge as existing only in relationship to groups and tools is problematic. He believes, as have many

philosophers before him, that knowledge exists in its own right and is not bound to a particular culture.

Other concerns regarding situated cognition focus on transfer (Anderson, Reder, & Simon, 1996; Bereiter, 1997). Situated cognitive theory suggests that learning consists of being attuned to the environment. As one becomes more learned in a particular community of practice, what is being learned becomes less able to be generalized and transferred. Bereiter (1997) is further concerned with not only the transfer of knowledge and skills, but also with the transfer of learned intelligent behavior. If we look at it from the situated perspective, intelligent behavior means becoming more and more attuned to one specific environment, which would appear to impede the transfer of knowledge and skills. While this does not inhibit transfer to similar environments, it does seem to hinder learned intelligent behavior to novel situations. This prohibits creation and adaptation of knowledge to new environments. Some tasks may be bound to the situation, but Bereiter argues part of being human, of "outgrowing our animal cognition" (p. 283), lies in our ability to transform our physical and social environments, not attune to it. If situated cognition is the standard of learning and therefore all knowledge is tied to specific environments, he fears progressions would not occur. At the very least, it would be left to the few elite who understand how to transcend the environment. His criticism with situating knowledge is not just in the inability to transfer, but also with the inability to progress.

Proponents of Socio-historical theory believe the mind, learning and knowledge are not solely located in the individual but also include environment, culture, tools and social interactions. This is a shift from the standard view of learning which sees the novice as an empty vessel that is "filled" by the teacher or boss. Vygotsky and other socio-historical theorists do not limit cognition to one person's mind, but incorporate social groups and materials as

indispensable components of learning. This allows for extremely complex work tasks to be performed by including varied and multifaceted systems such as cultures and tools.

The business literature does not have a theoretical framework to defend why many issues, like knowledge work, are essential for success in the Knowledge Age**.** They address the issue by claiming the expanse of expertise needed to conduct knowledge work calls for it to be done in a group. Socio-historical literature offers a more sophisticated theory, and provides a framework to understand many issues in the Knowledge Age. With an understanding of this theory one can postulate knowledge work groups exist not because of expertise, as the business literature suggests, but because learning must occur within social practice. It further states the tools created by the 'culture' must be understood through use and adaptation of cultural beliefs. The most important advancement socio-historical theory brings to our development of a new epistemology for the Knowledge Age is bringing the mind and learning out of the individual head and into tools and communities of practice. Maybe the Knowledge Age and Socio-historical theory lead us to reconsider knowledge as residing in the society and social practices rather than just in one person's mind. We are not concerned with mere collaboration but with an explanation for knowledge work that includes knowledge within the social network. According to some educational theorists, no longer is learning and knowledge situated in the individual mind. Business literature suggests that today's tasks require socialization and are too complex to be solved alone. Requirements for workers have changed and businesses have re-organized their work environments to accommodate complex tasks, but surely this change stems from something deeper than our commonsense beliefs. Paavola, Lipponen, & Hakkarainen, (2004) believe knowledge

creation (and thereby knowledge work) "…is not conceptualized through processes occurring in individuals' minds, but through processes of participation in social practices" (p. 569).

Even though moving knowledge and cognition outside of the individual's mind is a dramatic and important change in many areas, what Socio-historical theory does not do quite as well is to establish a comprehensive epistemology adequate for the Knowledge Age. A major conflict is the conception of knowledge as a tool and no real articulation of what constitutes knowledge objectification. Success in the Knowledge Age requires people to be innovative with knowledge on a regular basis. If knowledge is so bound to the situation, then knowledge work, which thrives on knowledge innovation, seems a difficult concept to reconcile within the theoretical framework. It appears, to be successful in the Knowledge Age, not only does knowledge need to be brought out of the individual mind and into social practice, there also needs to be an understanding of knowledge as autonomous and independent if we expect people to begin to work with, improve and manipulate the knowledge itself.

Deep Constructivism-Knowledge Building. With the need of a changing understanding of knowledge documented in the business literature, and having education at its core, a fundamental question becomes "What is the best educational theory to address the issues presented in the Knowledge Age?"

The Knowledge Age requires us to reexamine our prevalent theories of education. Historical educational theory states that there is a finite body of knowledge and it is the job of the teacher to "fill" students' heads with that knowledge. Socio-historical theory and Constructivism offer more progressive theoretical frameworks than the standard model, but still falls short, in my

view, of fulfilling the requirements for the Knowledge Age because it fails to adequately address knowledge improvement and knowledge objectification. If, as the business literature suggests there needs to be fundamental shift in our understanding of knowledge, does education have an epistemology adequate to meet the needs of the new Knowledge Age?

Expanding on Karl Popper's Worlds of Knowledge, Bereiter and Scardamalia and Bereiter's theory of Knowledge Building effectively addresses the issues presented in the Knowledge Age. Knowledge Building involves continual improvement of ideas through the creation of conceptual artifacts. In contrast to the traditional and Socio-historical model, Knowledge Building with its concept of knowledge objectification allows knowledge to be pried out of individual minds and social practice and allows knowledge to be, "…an object of constructive practice in its own right" (Bereiter & Scardamalia, 1998, p. 691). If as the business literature states, successful members of the Knowledge Age must be able to work with and improve knowledge, Knowledge Building with its articulation of knowledge objectification and conceptual artifacts appears to be a promising theory for education in the Knowledge Age.

Worlds of Knowledge. Some theorists (Bereiter, 2002a, b; Bereiter & Scardamalia, 1998; Bereiter & Scardamalia, 1996; Popper, 1972) propose that the understanding of three worlds of knowledge is necessary because, "…the knowledge of the knowledge society will be fundamentally different from what was considered knowledge in earlier societies" (Drucker, 1994, p. 9). Popper (1972) theorized an understanding of reality, which is divided into three Worlds of Knowledge. World One is the physical world that consists of physical objects that can be studied. World Two recognizes knowledge as subjective, mental objects, which includes opinions and personal explanations of phenomenon. World Three is the world of ideas. World Three knowledge consists of

abstract knowledge products represented by artifacts that generate further thought and development. These Three Worlds of Knowledge are not independent of each other or hierarchical in nature, but rather they exist simultaneously and continually impact and affect one another. World One knowledge (physical objects) affects and interacts with our World Two knowledge (personal beliefs). Further our World Two knowledge will drive the developmental path and theories created in World 3 (Objective knowledge), which can then impact the physical world (World 1**).**

Knowledge Building. Applications of Popper's conception of three worlds of knowledge to education, articulate an understanding of knowledge, learning, and school environment that some term "Deep Constructivism" or "Knowledge Building" (Scardamalia & Bereiter, 2003). In this theory, learning is defined as an undetectable internal process resulting in a behavior or skill change as well as the distribution of the cultural capital of a society. It is a change in a World 2 belief, a change in what "I" think or believe about a particular topic. While they do acknowledge learning as an integral part of education with many valuable attributes, the focus is on Knowledge Building (Scardamalia & Bereiter, 2003). Commonly misunderstood in education to be a synonym of learning, Knowledge Building in this view is actually, "… production and continual improvement of ideas of value to a community …" (Scardamalia & Bereiter, 2003 p. 1371). When successful, it results in the creation or modification of public knowledge and helps get ideas out into the world for further critique and improvement. Knowledge Building happens from the interaction between World 1, World 2 and World 3. When done successfully this interaction produces changes in World 3 objects. Knowledge creation and innovation are at the core of what it means to be working in World 3.

Knowledge Building incorporates the traditional focus of school, World 2 knowledge (learning) and takes it one step further by incorporating World 3 knowledge that allows for advancement through critiques and creative use of knowledge. Scardamalia & Bereiter believe the traditional focus of schools is to teach the established cannon of knowledge and useful cognitive skills (1994). But in order to adapt to the changing world based on knowledge creation and innovation, they believe schools must enculturate students in the world of Knowledge Building-- World 3**.** Schooling would then incorporate physical objects (World 1), what is in students heads/what the student knows (World 2) and the progression of knowledge objects (World 3). Traditionally students see the information presented in school as definitive, but to understand Knowledge Building they must shift to the idea that knowledge is constantly changing, improving and debatable, a characteristic established as critical in the new knowledge society. While this may appear a little overwhelming for the average student and average classroom, Knowledge Building, knowledge autonomy, knowledge improvability (in total the activity in World 3) need not: "… always have to be creative but it must … render the knowledge more meaningful, accessible … or reliable to particular purposes" (Bereiter and Scardamalia, 1998 p. 677). It can be as straightforward as a five-word phrase written as a subject title in Knowledge Forum (a shared networked database developed by Scardamalia, Bereiter, and colleagues), "Mendel worked on Karen's problem" (Scardamalia, Bereiter, & Lamon, 1994, p. 210). Those five words demonstrate how Knowledge Building can be a process in the everyday classroom. It distills the connection between subjective knowledge (world 2), the idea of objectifiable improvable knowledge (world 3) and epitomizes the realization that this problem, "… mattered to other people. By working on it they became a part of something

larger" (Scardamalia, Bereiter, & Lamon 1998 p. 211). By Knowledge Building and working in World 3, students can become a part of the long tradition and dialogue, " … aimed at understanding the nature of things" (Scardamalia, Bereiter, & Lamon 1998, p. 210). In other words they become enculturated into World 3 and the creation of knowledge objects.

Because this is such a shift in our understanding of learning and the classroom a few questions arise like, "What would take place in a knowledge-building classroom?" and "what would be the guiding principles and processes for both teachers and students?" Scardamalia (2002) has identified 12 principles of Knowledge Building:

1. real ideas
2. authentic problems
3. improvable ideas
4. idea diversity
5. rise above
6. epistemic agency
7. community knowledge-collective responsibility
8. democratizing knowledge
9. symmetric knowledge advancement
10. pervasive knowledge building
11. constructive use of authoritative sources
12. knowledge building discourse.

While she has identified 12 specific principles to Knowledge Building, only five of these principles have been discussed repeatedly in business knowledge work literature.

The five principles discussed as core ideas for knowledge workers are: improvable ideas (3), idea diversity (4), epistemic agency (6), constructive uses of authoritative sources (11), and knowledge building discourse (12)**.** Therefore the following discussion will concentrate on the above five principles.

In order for *improvable ideas* to become a characteristic in the classroom all ideas should be treated as though they are subject to change and nothing should be considered an ultimate truth**.** It is also important that students spend class time revising the utility of an idea in an environment where they feel safe enough to suggest any theory or improvement without fear of ridicule or scorn**.** *Idea diversity* is necessary in a Knowledge Building community because it recognizes all knowledge related to the topic, especially that which contradicts it, can help advance our understandings. Diversity and conflict can help contextualize the idea, as well as help strengthen the idea or suggest it needs replacing. *Epistemic agency* requires students to propose their own ideas for solving the problem and use conflicting ideas to help support knowledge advancement of the group. Long term planning goals and evaluation are designated student responsibilities. *Constructive use of authoritative sources* implements many of the ideas presented in idea diversity but focuses more on the conflicting views within a particular discipline. Because students are involved in improving knowledge objects, they should be in touch with past and current thought in the field of specialty. It is suggested that while students remain respectful of the authoritative sources, they should also keep an objective and critical stance from them as well.

The last component is a *knowledge building discourse*. Because the discourse in Knowledge Building does more than share knowledge, the discursive interactions often

result in knowledge improvement; it is a critical component that has been further divided into three subcategories: *focus on problems and depth of understanding, decentralized open knowledge building with a focus on collective knowledge and the broader knowledge community* (Scardamalia & Bereiter, 1994). When students *focus on problems and depth of understanding,* they are looking at the problem from the perspective of underlying principles and how things work. They are seeing the interconnectedness of seemingly unrelated ideas, instead of focusing on topics or categories of knowledge**.** *Decentralized open knowledge building* concentrates on what all members of the knowledge building community can bring to knowledge advancement**.** In a knowledge-building classroom, teachers and more knowledgeable students do not stand on the outskirts of the discussion and direct the process. Even though they may have more knowledge than the other students, they are actively engaged in knowledge building with the rest of the class. The less knowledgeable participants play a significant role by asking questions that result in challenging the status quo and for driving clarification of knowledge. It is hoped asking questions and asking for further clarification, could show the more knowledgeable students the gaps and flaws in the theory that need to be addressed. The final category of knowledge building discourse opens the *discussion to the broader knowledge community*. It allows for diversity of ideas on a broader level that may further the discussion of how the idea can be improved. A familiar example of this characteristic is the peer review journal process. Here the motivation for the lengthy and sometimes unrewarding process is to put one's work into the "…construction of collective knowledge…" (Scardamalia & Bereiter, 1994 p. 272) so the multiple perspectives can allow the author to revise and improve the original idea.

Even with the apparent benefits of a Knowledge Building classroom establishing these ideas in a traditional classroom presents some concerns (Scardamalia, 2002). If Knowledge Building and learning are separated how do we assess what students have learned from these Knowledge Building activities? How will students perform? In comparison to control groups, students in Knowledge Building classrooms scored significantly better on reading and language skills and were on par for other academic areas. The most substantial difference students in the Knowledge Building classroom demonstrate is the aptitude to take on the clarification of knowledge problems (Scardamalia, 2002). Other concerns include motivation, furthering misconceptions, and the idea that students must learn first and do second**.** While these are valid concerns that need to be addressed, they are issues pertinent to all education, not just the Knowledge Building classroom.

In a Knowledge Building classroom, how do all of the stakeholders in education (teachers, parents, school administrators, students, and taxpayers) determine and assess the quality and quantity of learning that has taken place? What are the students working on? When students are knowledge building in World Three, working with and improving ideas, they are working on conceptual artifacts (Bereiter, 2002b). Conceptual artifacts are debatable, independent, objectifiable, and improvable ideas**.** These artifacts, which can consist of anything from a blueprint to a recipe, are discussable ideas or theories (conceptual) that are human creations (artifacts). One might argue a blueprint or recipe is actually a physical thing, a material artifact. The distinction between the two can be difficult to decipher and an example comparing the automobile versus the automobile design may help clarify the idea (Bereiter, 2002a). The physical car one drives around

each day is a material artifact, but the design for the car created by engineers is a conceptual artifact. A component of a conceptual artifact is that it must show improvement over its predecessor. It has to take into consideration the advancements in knowledge or overcome a previous model's flaw. In the car example, it is assumed that a new model is created in order to capture new technologies or knowledge that improve the style, performance, safety, or other features of the automobile. The general population will assume that this model is better (not the best) than the previous model, be it because it has a more attractive exterior, better gas mileage or better safety features. The plan or blueprint for the new car is a conceptual artifact and the physical changes in the car, more airbags, sleeker exterior, are material artifacts. It is important to note that improvements upon conceptual artifacts are never considered the "best", simply improvements. When a computer company releases its latest desktop it is assumed this model is much better than the next but few people would venture to say it is the best computer that can *ever* be created. A previously stated characteristic of Knowledge Building, which creates conceptual artifacts, is *improvable ideas*. It is an important characteristic of this theory that no idea is considered an ultimate truth. Conceptual artifacts are improvements, which can still allow for "tinkering" from other people.

Bereiter (2002b) proposes that the new classroom should create and improve conceptual artifacts through Knowledge Building. Students' endeavors in the classroom involve the formation of conceptual artifacts by understanding knowledge as creatable, something that can be worked with and improved upon. For this idea to take hold, educators need to shift their understanding of knowledge as facts stored in their individual minds to ideas that are out there in the world, independent of them (i.e., World Three).

With this conception, students can no longer be passive receivers of theories but they have to take a more active role by reconstructing it starting with the problem it was intended to solve. Students can then see theories as a tool for explaining phenomena and start asking the questions, "what is this good for?" and "how can it be improved?" (Bereiter, 20002b, p. 22).

Approach to Knowledge Scheme- Levels of knowledge objectification. To help students become the new knowledge workers, Bereiter and Scardamalia (1998) suggest that educators adjust their view of knowledge and educational practice to one that allows students to work with and improve knowledge. For that reason, Karl Popper's (1972) Three Worlds of Knowledge and the theory of Knowledge Building has been expanded through the creation of an Approach to Knowledge Scheme, which includes three approaches to knowledge with seven embedded levels (Table 1) (Bereiter & Scardamalia, 1998)**.**

Table 1 Theoretical Perspective

Popper (1972)	**Bereiter & Scardamalia (1998)**
World 1 Physical world consists of physical objects to be studied	Level 0 "Knowledge as individuated mental states. Children realize that one person may know something that another does not. Thus, implicitly, there is some entity—a fact--which a person may or may not know" (Bereiter & Scardamalia, 1998, p. 1). "JWA: Look, here's a box. Child: Smarties! [small candies] JWA: Let's look inside. Child: Okay. JWA: Let's open it and look inside. Child: Oh... holy moly... pencils! JWA: Now I'm going to put them back and close it up again. (Does so) Now...when you first saw the box, before we opened it, what did you think was inside it? Child: Pencils. JWA: Nicky (child's friend) hasn't seen inside this box. When Nicky comes in and sees it... When Nicky sees the box, what will he think is inside it? Child: Pencils" (Bereiter

	& Scardamalia, 1998, p.2).
	Level 1 “Knowledge as individuated mental states. Children realize that one person may know something that another does not. Thus, implicitly, there is some entity—a fact--which a person may or may not know” (Bereiter & Scardamalia, 1998, p.1). “In one study, two stuffed animals made of the same gray material, say an elephant and a rabbit, were hidden in separate boxes, each with a little hole in the lid. Only the gray material and nothing else that would identify the animal could be seen through the hole. The experimenter pointed to one box and said, "Do you know it's the elephant in here?" and also asked whether someone else would know. A good number of four-year olds and most five-year-olds recognize that if you saw the animals being put into the boxes you would know, but if you weren't there and didn't see it, you can't know which animal it is if you see only the gray patch through the hole in the lid” (Bereiter & Scardamalia, 1998, p.2).
	Level 2 “Knowledge as itemizable mental content. Children can relate things they know about a topic, and often delight in doing so. Thus, implicitly, knowledge consists of sortable items” (Bereiter & Scardamalia, 1998, p.1). “Yesterday we talked about the human eye. It was very complicated but it was also fun. I learned that the human eye is protected by three layers of tissue. I also learned the different parts on the eye like the Cornea, Lens, Pupil, Iris, Fovea, Vitreaous, Aqueous, Ciliary, Retina and Conjunctiva. The Vitreous humour and the aqueous humour is like the jelly in your eyes and it protects everything behind them. I also learned that your eyes are one of the most complex organ of our body. The Aqueous humour is transparent, and the Vitreous humour is transparent. I also learned... [and so on for another 100 words]” (Bereiter & Scardamalia, 1998, p.3).

World 2 Knowledge is subjective mental objects	Level 3 "Knowledge as representable. In trying to communicate what they know to a reader, students take into account what the reader already knows and is in a position to understand. Thus knowledge is no longer just something in the head to be expressed but is something to be represented, shared, interpreted by others" (Bereiter & Scardamalia, 1998, p.1). "Don't you wonder how you see things? Well it works like this: When you look at something, the light (white light) bounces into your eyes which forms a picture in the back of the eye. The picture (upside down) travels into your brain. In one part of your brain the shape and colour are put together. In another part of the brain adds the movement and depth. Then it flips the picture over. The white light that goes into your eye is made from the primary colours, red green and blue. It's hard to believe that three colours, makes you see all the colours in the world" (Bereiter & Scardamalia, 1998, p.3).
	Level 4 "Knowledge as viewable from different perspectives. Students see that the same knowledge can appear in different contexts and can be viewed from different perspectives. This is an important step toward objectification" (Bereiter & Scardamalia, 1998, p.1). "In a classroom experiment by Ward and Thiessen (19xx), third-graders, studying endangered species, each produced a CSILE note describing a different endangered species in their region, its habitat, source of endangerment, and so on--a fairly common activity up to this point. However, using CSILE's note-linking capabilities, the students all linked their notes to appropriate points on a map of a region, thus allowing students to see what species were near each other or shared the same habitat. They also linked their notes to a phylogenetic tree, allowing them to see biological relationships among their species. Finally, the students themselves worked out a set of reasons for endangerment, and linked their notes to appropriate boxes in a diagram of these reasons, thus affording a third perspective on the same body of knowledge" (Bereiter & Scardamalia, 1998, p.3).

	Level 5 “Knowledge as personal artifacts. Although constructivism is widely endorsed by teachers, it is not common for young students to view themselves as constructors of knowledge. Viewing oneself as constructing knowledge is a large step beyond viewing oneself as constructing knowledge representations” (Bereiter & Scardamalia, 1998, p.3). “I think that I can tell if I've learned something when I'm able to form substantial theories that seem to fit in with the information that I've already got; so it's not necessarily that I have everything, that I have all the information, but that I'm able to piece things in that make sense and then to form theories on the questions that would all fit together. Although this was the most articulate response, the responses of other students in the class were consistent with it” (Bereiter & Scardamalia, 1998, p.3).
World 3 World of ideas	Level 6 “Knowledge as improvable personal artifacts. A theory or other knowledge object is viewed in terms of what it can and cannot do, what its virtues are and where it is in need of improvement , although still viewed as a personal possession” (Bereiter & Scardamalia, 1998, p.2). “I've learned a lot. My theory wasn't even close to right. So I thought it was because a tree would freeze, but then I realized that a tree probably couldn't freeze. I don't know about that because me and the kid that's working are still kind of writing. But I thought it was probably just because of the water would freeze and now I realize that its not--its definitely not just the water. There's the wind, nutrients, and the permafrost, and the daylight and everything basically plays a factor in it so...” (Bereiter & Scardamalia, 1998, p.4).
	Level 7 “Knowledge as semi-autonomous artifacts. Students recognize that knowledge objects, like other constructed objects, can take on a life of their own and may be considered independently of their personal relevance. Thus, at this level, knowledge objects become things that one can relate to, use, manipulate, judge in various ways, and have feelings about--just like other things in the real world” (Bereiter & Scardamalia, 1998, p.2).

	"I think that Newton's theory is agreeable, but if the particles in space were attracted to each other the whole solar system would have been moving in all directions so it would be torn apart. OOPS! I just thought of something, The sun is holding the solar system together" (Bereiter & Scardamalia, 1998, p.4).

The perspectives demonstrated in Approach I and II include knowledge as individuated mental states, listable mental content, representable, and as viewable from different perspectives. These first two Approaches offer a developmental view that is a well-documented part of educational theory (Bereiter & Scardamalia, 1998). What is new to educational theory is Approach III. Approach III consists of three levels: knowledge as personal artifacts (level 5), knowledge as improvable personal artifacts (level 6) and knowledge as semi-autonomous artifacts (Level 7). When students are working at level 5, knowledge as personal artifact, they begin to see themselves as the constructors of knowledge itself. They start to piece together theories that fit with preexisting understandings and make sense of the knowledge for themselves. Students can articulate an idea as "my theory" and begin to see knowledge as evolving, although the student's idea still hold the protected status of personal opinion. Level 6, knowledge as improvable personal artifacts, holds many of the same understandings as level 5 while allowing for a more mature view of the student's personal theory. In this level students see their theories in terms of what it can and cannot do, where it needs improvement and what its virtues are. This is an important shift because it demonstrates a completely different

conceptualization of knowledge as something that is evolving and constantly improving. Knowledge is still understood as something personal and thereby still receives the protected status of an opinion. A fifth grade student functioning at level 6 responded to a question about learning by saying, "I think that I can tell if I've learned something when I'm able to form substantial theories that seem to fit with the information I've already got … I'm able to piece things in that make sense …" (Bereiter & Scardamalia, 1998, p. 688). At level 7, knowledge as semi-autonomous artifacts, students view knowledge as independent from themselves. At this level knowledge is completely understood in terms of knowledge objects, which are independent of the user. No longer are theories viewed with the protective status of personal opinions. They are now understood as knowledge objects to be criticized, judged and manipulated. "At this stage, then, 'knowledge work' becomes readily comprehensible … it involves adding value; but in this case the things one adds value to are knowledge objects" (Bereiter & Scardamalia, 1998, p.689). What this scheme offers is an essential change in our understanding of knowledge that coincides with the Knowledge Age-- knowledge objectification. Objectification is the, "… prying loose of knowledge from individual mental states and collective practices, making it an object of constructive practice in its own right" (Bereiter & Scardamalia, 1998, p. 691). This is exactly the idea of Approach III.

If education changes its view of knowledge to be an object of "constructive practice", it becomes possible to have a conception of knowledge that is coherent with the expectations of the Knowledge Age. If, a worker's job includes knowledge improvement, then there needs to be a conception of knowledge as objectifiable, autonomous and improvable. In essence a worker needs to be functioning at Approach III. It must be noted that working within any given

approach does not necessarily imply an intense understanding of knowledge in that subject area, however, students are in the position to take a constructive role in the pursuit of knowledge creation.

While Bereiter and Scardamalia (1998) have examined students' experiences with the Approach to Knowledge Scheme, information about teachers' experiences is limited. Recent research on teacher epistemology suggests teachers' beliefs have an important impact on students' beliefs. Studies examining the impact of teachers' understanding of their domain specific knowledge revealed that not only is it important that teachers have domain specific knowledge (e.g., Shulman 1986, 1987), but that their views of knowledge in their domain influence their expectations of their students, how they teach, and how they assess students (Chan & Elliot, 2004; Johnson, Woodside, & Day, 2001; Kang & Wallace, 2004). The teachers in these studies had instructional goals, behavioral expectations, classroom rules, and educational philosophies consistent with their epistemological beliefs about their subject matter. Johnson and his colleagues (2001) found that the discourse environment and teachers' epistemological beliefs could shape the epistemology of the children in their classroom. Furthermore, their findings indicate how a teacher perceives knowledge, its importance, how it is best understood, and what aspects of the discipline are important, all influence how the teacher presents and assesses the information. For example, if teachers only present knowledge as memorizable facts, and present and assess the students in a way consistent with their philosophy, their students are more likely to perceive knowledge in the same way they do. The same is true of teachers who understand knowledge as a process of refining and further understanding of ideas.

Taking this literature into consideration, Keefer and Ruffus (2004) adapted Bereiter and Scardamalia's (1998) Approach to Knowledge Scheme to include teachers' understanding of

knowledge through their views on knowledge, teaching, curriculum and assessment (KTCA) (see Table 2). They applied this Scheme to interviews of expert and novice teachers. Not only did Keefer and Ruffus (2004) find the Scheme applicable to teachers' understanding of knowledge, teaching curriculum and assessment, they also found differences in the quantity and levels of approach between novice and expert teachers as coded by the Scheme. Ruffus Doerr et al. (2007) further standardized the methodology with teachers.

Table 2: Comparison of the Approach to Knowledge Scheme Bereiter & Scardamalia (1998) to Keefer & Ruffus (2004)

Bereiter & Scardamalia (1998)	**Keefer & Ruffus (2004)**
Level 0 "Knowledge as individuated mental states. Children realize that one person may know something that another does not. Thus, implicitly, there is some entity—a fact--which a person may or may not know" (Bereiter & Scardamalia, 1998, p. 1). "JWA: Look, here's a box. Child: Smarties! [small candies] JWA: Let's look inside. Child: Okay. JWA: Let's open it and look inside. Child: Oh... holy moly... pencils! JWA: Now I'm going to put them back and close it up again. (Does so) Now...when you first saw the box, before we opened it, what did you think was inside it? Child: Pencils. JWA: Nicky (child's friend) hasn't seen inside this box. When Nicky comes in and sees it... When Nicky sees the box, what will he think is inside it? Child: Pencils" (Bereiter & Scardamalia, 1998, p.2).	
Level 1 "Knowledge as individuated mental states. Children realize that one person may know something that another does not. Thus, implicitly, there is some	Level 1 "Teacher's approach to knowledge, teaching curriculum and assessment (KTCA) is oriented toward a view of knowledge as consisting of correct and incorrect facts" (Keefer & Ruffus,

entity—a fact--which a person may or may not know" (Bereiter & Scardamalia, 1998, p.1). "In one study, two stuffed animals made of the same gray material, say an elephant and a rabbit, were hidden in separate boxes, each with a little hole in the lid. Only the gray material and nothing else that would identify the animal could be seen through the hole. The experimenter pointed to one box and said, "Do you know it's the elephant in here?" and also asked whether someone else would know. A good number of four-year olds and most five-year-olds recognize that if you saw the animals being put into the boxes you would know, but if you weren't there and didn't see it, you can't know which animal it is if you see only the gray patch through the hole in the lid" (Bereiter & Scardamalia, 1998, p.2).	2004, p. 5) "Just as in with Boon Meadows they have such a hard time getting away from the fact that flying isn't faster. … It is sort of counter-intuitive in a way" (Keefer & Ruffus, 2004, p. 5).
Level 2 "Knowledge as itemizable mental content. Children can relate things they know about a topic, and often delight in doing so. Thus, implicitly, knowledge consists of sortable items" (Bereiter & Scardamalia, 1998, p.1). "Yesterday we talked about the human eye. It was very complicated but it was also fun. I learned that the human eye is protected by three layers of tissue. I also learned the different parts on the eye like the Cornea, Lens, Pupil, Iris, Fovea, Vitreaous, Aqueous, Ciliary, Retina and Conjunctiva. The Vitreous humour and the aqueous humour is like the jelly in your eyes and it protects everything behind them. I also learned that your eyes are one of the most	Level 2 Teacher's approach to KTCA infers that knowledge is list or set of sortable items" (Keefer & Ruffus, 2004, p. 5). "What are some of the marine organisms in the ocean, at what different levels, what about pollution of the ocean, what are some of the worst kind of pollution" (Keefer & Ruffus, 2004, p. 5).

complex organ of our body. The Aqueous humour is transparent, and the Vitreous humour is transparent. I also learned... [and so on for another 100 words]" (Bereiter & Scardamalia, 1998, p.3).	
Level 3 "Knowledge as representable. In trying to communicate what they know to a reader, students take into account what the reader already knows and is in a position to understand. Thus knowledge is no longer just something in the head to be expressed but is something to be represented, shared, interpreted by others" (Bereiter & Scardamalia, 1998, p.1). "Don't you wonder how you see things? Well it works like this: When you look at something, the light (white light) bounces into your eyes which forms a picture in the back of the eye. The picture (upside down) travels into your brain. In one part of your brain the shape and colour are put together. In another part of the brain adds the movement and depth. Then it flips the picture over. The white light that goes into your eye is made from the primary colours, red green and blue. It's hard to believe that three colours, makes you see all the colours in the world" (Bereiter & Scardamalia, 1998, p.3).	Level 3 "Teachers' approach to KTCA and stresses understanding that knowledge can be represented, interpreted and communicated" (Keefer & Ruffus, 2004, p. 5). "Mathematics is a tool to communicate quantitative information. ... The study of mathematics gives you the words and the tools that you can communicate what you see happening in a situation. The patterns that you see" (Keefer & Ruffus, 2004, p. 5).
Level 4 "Knowledge as viewable from different perspectives. Students see that the same knowledge can appear in different contexts and can be viewed from different perspectives. This is an important step toward objectification" (Bereiter & Scardamalia, 1998, p.1).	Level 4 "Teachers' approach to KTCA focuses on the significance of understanding knowledge from different perspectives, which can help the students to a deeper understanding of the problem" (Keefer & Ruffus, 2004, p. 5). "And that way, when pod 3 hears pod 2 hearing

"In a classroom experiment by Ward and Thiessen (19xx), third-graders, studying endangered species, each produced a CSILE note describing a different endangered species in their region, its habitat, source of endangerment, and so on--a fairly common activity up to this point. However, using CSILE's note-linking capabilities, the students all linked their notes to appropriate points on a map of a region, thus allowing students to see what species were near each other or shared the same habitat. They also linked their notes to a phylogenetic tree, allowing them to see biological relationships among their species. Finally, the students themselves worked out a set of reasons for endangerment, and linked their notes to appropriate boxes in a diagram of these reasons, thus affording a third perspective on the same body of knowledge" (Bereiter & Scardamalia, 1998, p.3).	where they are where and they need to go, they may not have thought to go there. Or then they're saying why are they going there? What are they going to gain from having gone there? So it brings up such a higher level thinking processes in the group that didn't think to go there" (Keefer & Ruffus, 2004, p. 5).
Level 5 "Knowledge as personal artifacts. Although constructivism is widely endorsed by teachers, it is not common for young students to view themselves as constructors of knowledge. Viewing oneself as constructing knowledge is a large step beyond viewing oneself as constructing knowledge representations" (Bereiter & Scardamalia, 1998, p.3). "I think that I can tell if I've learned something when I'm able to form substantial theories that seem to fit in with the information that I've already got; so it's not necessarily that I have everything, that I have all the information, but that I'm able to piece	Level 5 "Teachers' approach to KTCA conceptualizes knowledge in terms of personal artifacts" (Keefer & Ruffus, 2004, p. 5). "1 think the best way for students to learn math is once they develop a wonder, a "what if What happens if I do this? What happens if I do that? And out of that what if, then they see general patterns and then they can build on those patterns. It's not just a rote memorization of facts. You have to have that as a tool" (Keefer & Ruffus, 2004, p. 6).

things in that make sense and then to form theories on the questions that would all fit together. Although this was the most articulate response, the responses of other students in the class were consistent with it" (Bereiter & Scardamalia, 1998, p.3).	
Level 6 "Knowledge as improvable personal artifacts. A theory or other knowledge object is viewed in terms of what it can and cannot do, what its virtues are and where it is in need of improvement , although still viewed as a personal possession" (Bereiter & Scardamalia, 1998, p.2). "I've learned a lot. My theory wasn't even close to right. So I thought it was because a tree would freeze, but then I realized that a tree probably couldn't freeze. I don't know about that because me and the kid that's working are still kind of writing. But I thought it was probably just because of the water would freeze and now I realize that its not--its definitely not just the water. There's the wind, nutrients, and the permafrost, and the daylight and everything basically plays a factor in it so..." (Bereiter & Scardamalia, 1998, p.4).	Level 6 "Teachers' approach to KTCA is to see themselves as users and improvers of knowledge. Knowledge is conceived as objective, it can be defended, improved, or effectively critiqued" (Keefer & Ruffus, 2004, p. 5). "…Secondly I don't want them to think that it's [the measurement of angles] an isolated activity done only in math class, because we have to apply our understanding of angles in many other areas of our life. So I chose this because…it is an expansion of where they can decontextualize and recreate something new from the knowledge that they have, which is important for them" (Keefer & Ruffus, 2004, p. 6).

Level 7 "Knowledge as semi-autonomous artifacts. Students recognize that knowledge objects, like other constructed objects, can take on a life of their own and may be considered independently of their personal relevance. Thus, at this level, knowledge objects become things that one can relate to, use, manipulate, judge in various ways, and have feelings about--just like other things in the real world" (Bereiter & Scardamalia, 1998, p.2). "I think that Newton's theory is agreeable, but if the particles in space were attracted to each other the whole solar system would have been moving in all directions so it would be torn apart. OOPS! I just thought of something, The sun is holding the solar system together" (Bereiter & Scardamalia, 1998, p.4).	Level 7 "Teachers' approach to KTCA is oriented towards an understanding that knowledge consists of deep principles that are conceptual artifacts and can be applied to problems" (Keefer & Ruffus, 2004, p. 5). "well the mathematics big idea is that [pause] … – you can do a lot with the same amount of area based on the discussions that you make. Um, you have many many choices given a finite amount of space. [pause] You have to then decide how to allocate that space … In social studies they would have said 'You only have a finite amount of space and you must meet societal needs. How will you do that?' In science they would have said 'You only have a set amount of area and you must sustain life, how are you going to do that?'" (Keefer & Ruffus, 2004, p. 6).

As a part of the constructivist movement, Worlds of Knowledge and Knowledge Building present an educational theory consistent with the Knowledge Age. Considering that Knowledge Building may seem difficult to implement in the classroom, Scardamalia (2002) offers 12 characteristics for teachers to follow in order to establish an environment conducive for Knowledge Building. The five components discussed (improvable ideas, idea diversity, epistemic agency, constructive uses of authoritative sources, and Knowledge Building discourse) are all features that are being stressed in the business environment. The critical piece, Knowledge Building, offers to education is the idea of World Three. World Three, with its understanding of conceptual artifacts and knowledge objectification, offers a conceptualization of knowledge as: autonomous, improvable, progressive, and debatable. This idea is consistent

with the necessary characteristics in the Knowledge Age. Autonomy, moving knowledge out of the individual and out of the group into a space of its own, is the progression over previous theories in education. If knowledge is thought of as an independent semi-autonomous artifact, it loses the protective status of personal opinions, or what "I know" (World 2) about a topic. It can then be thought of as something independent that can be discussed, critiqued and improved.

With the documented change from the Industrial Age to the Knowledge Age, knowledge is becoming far more important than previously thought (Bereiter & Scardamalia, 1998). "As we move from the Industrial Age into the Information Age, knowledge is becoming a key driver for the competitive success of firms and even nations" (Martinez-Torres, 2006, p. 617). The business literature asserts that the move into the Knowledge Age requires people to be familiar with using and improving knowledge (Bell, 1973; Drucker, 1959; Machlup, 1998; Pyoria, 2005). However, there is little mention of improving knowledge explicitly in education. In fact, there is a growing sentiment that education is not preparing students to be productive members of the new Knowledge Age. If we expect to prepare our students to be productive workers and citizens in the 21st century, a new conception of knowledge needs to be considered with schools as the cornerstone for this new understanding (Griffith, 2005; King, 2006; Reich, 2005). Considering that the school system is a foundation for learning, it is a startling revelation that education reform has not focused more explicitly on knowledge work. Bereiter and Scardamalia (1998) have begun the discussion in education, with their research on the Approach to Knowledge Scheme tested on middle school students. In view of the research related to the impact a teacher's epistemology has on student epistemology, it appears an important question to ask is: "What are teachers'

epistemological and pedagogical beliefs and how do those beliefs affect their roles in educating students for the Knowledge Age?”

Chapter 3

Methodology

As suggested by reviewing relevant literature, Knowledge Building appears to be a promising epistemology for education in the Knowledge Age. Ideas central to the Knowledge Building theory model are conceptual artifacts and knowledge objectification. If teachers have an epistemology consistent with this theory, they will see knowledge as autonomous, improvable, progressive and debatable. Scardamalia (2002) has outlined essential characteristics of knowledge-building classrooms, such as authentic problems, improvable ideas, idea diversity, and student responsibility for knowledge advancement termed "epistemic agency". Bereiter (2002b) also argues that an essential component of Knowledge Building and the inevitable outcome will be conceptual artifacts. These characteristics of Knowledge Building can also be seen in a problem based learning (PBL) classroom.

PBL is a pedagogical strategy of active learning where students are presented with ill-defined, realistic problems (authentic problems). In small groups, students are expected to create hypotheses to solve the problem and present possible solutions to the rest of the class (epistemic agency). Through the process of generating and defending hypotheses of realistic problems, students can begin to see knowledge as debatable and improvable. This process also allows the whole class to debate the strengths and weaknesses of each solution (improvable ideas). These student-generated solutions are debatable, autonomous, and improvable ideas (conceptual artifacts). Through this process students can see that there are multiple solutions to one problem (idea diversity).

These principles of Knowledge Building in a PBL environment can be seen in the K-12

public school system. For example as a part of the mathematics curriculum, *The Adventures of Jasper Woodbury* (1992), students are charged with designing a blueprint for the new school playground (authentic problem). The students are required to take theoretical mathematical knowledge and use it to create a blueprint to scale of their ultimate playground. In this unit the blueprint (conceptual artifact) allows students to use their knowledge of volume (sandbox), area (how many items they can place in the playground and of what size), angles (monkey bars and slide) and the Pythagorean Theorem (slide) to propose possible playground designs (epistemic agency). The groups then present their ideas to the rest of the class and decide on the best plan (idea diversity).

Another example can be seen in a middle school Science class, where students are posed with the problem that an area of the school grounds appears to be unable to grow grass (authentic problem). After researching, in groups, the impact of soil and climate on grass growth, the students generate and test possible hypotheses (epistemic agency). With the results of the tests and information from the research, each group independently presents possible solutions to the class (improvable ideas, idea diversity) and the class determines which plan (conceptual artifact) is the most viable option.

Considering these shared characteristics of problem based learning (PBL) and Knowledge Building, a PBL environment presented a setting to further investigate this promising epistemology for the Knowledge Age. The purpose of this investigation is to explore the principles of knowledge building in a PBL environment by exploring teachers' epistemological beliefs and pedagogical practices as well as the usefulness of the Approach to Knowledge Scheme.

Research Design

This collective case study (Berg, 2004; Stake, 1994) was designed to examine the following two research questions:

1.) What are teachers' epistemological beliefs and pedagogical practices in a PBL setting?

2.) Is the Approach to Knowledge Scheme an applicable tool to use with teachers and how can it be further modified to better reflect the ideas of the Knowledge Age?

Because there was little research in education on this topic, the research design for this study was largely exploratory. For this reason, a qualitative collective case study, which consists of multiple instrumental case studies, was used (Berg, 2004). A collective case study involves a study of multiple instrumental case studies, and therefore helps better understand or provide insight into a topic (Berg, 2004). An instrumental case study was also used to clarify a theoretical question or idea (Stake, 1994), help reveal interactions and significant characteristics of a theory (Berg, 2004) and promote an understanding of a specific concept (Stake, 1995). Because case studies that rely upon multiple forms of data have higher value and are more valid (Yin, 2003), three forms of data were collected to facilitate data triangulation during analysis: interviews (pre and post-observation), classroom observation, and a unit plan. As we are only interested in the relevant aspects of the theory, results will be reported in a theory building structure (Yin 2003).

Participants

This study involved an in-depth analysis of four individuals. In order to protect the participants' privacy, pseudonyms were used in this study. Considering that the purpose of the instrumental case study is to clarify a theoretical question or idea, theoretical sampling was the best fit. Theoretical sampling allowed researchers to choose participants based on the expectation they would be able to offer "…new insights for the developing theory" (Flick, 2002, p. 64).

The first step in choosing possible participants was to look for teachers who work in a problem based learning environment. Through online research of area schools in combination with suggestions from professionals, a few schools were determined to be school wide problem based learning environments. Once these schools were identified, an email was sent to all teachers in the schools. In order to determine the participants that could articulate epistemological beliefs consistent with the Knowledge Age, the researcher examined the participants' unit plans and informally engaged them in discussion. The researcher looked for teachers who promoted the ideas articulated in Approach III of the Approach to Knowledge Scheme, which articulates some of the ideas in Knowledge Building. Questions under consideration during the process included: were the students presented with realistic problems, were they allowed to deal with experts in the field, did the teacher promote debate, and were the students required to generate possible solutions?

When these criteria were met and the teacher was interested in participating in the study, the researcher scheduled two interviews and observation. The observation and interviews were arranged at the convenience of the participant.

All four participants for this study worked in the same Midwestern United States school district. This particular district has a total of five schools (pre-kindergarten through high school) with over 1100 students and a 12:1 student to teacher ratio. Nearly 90% of students graduate high school. The majority (over 55%) of students are Caucasian, almost 40% of students are African American, approximately 2% of students are Asian, and less than 1% American Indian. The median family income is nearly $36,000 with over 40% of the students qualifying for the free and reduced lunch program. The participating teachers will be described in more detail in Chapter 4.

Materials

Four different materials were used in this study: two interview protocols, a coding scheme and unit plans. The semi structured pre and post-interview protocols were based on previous research (Keefer & Ruffus, 2004; Ruffus-Doerr et al., 2007). Questions focused on teachers' understandings of content in their domain, and were found to elicit responses relevant to knowledge building and the Approach to Knowledge Scheme. Semi-structured interviews required pre-determined questions that were asked in a consistent manner with probes that allow for additional clarification (Berg, 2004). They also assumed that with the use of open-ended questions, participants were more likely to express their true viewpoints (Flick, 2002).

The first material, the pre-observation interview protocol, consisted of ten main questions that involve a general discussion of content knowledge, pedagogy, and assessment with probe questions for each of the main questions (see Appendix A). This interview protocol included such questions as: How do you know your students are knowledgeable in [content area]? How do you know your students have grasped a deep understanding of [content area]? What do you think might be the deep principles, enduring understandings, or concepts of [content area]? Do your students have the opportunity to critique the work of other students? Previous research results (Keefer & Ruffus, 2004; Ruffus-Doerr et al., 2007), suggested that these questions would help clarify the participants' attitudes towards the nature of knowledge, pedagogy, and assessment in their disciplines. Since participants were chosen based on their ability to illuminate the developing theory, their views were expected to help articulate an epistemology that is consistent with the Knowledge Age while modifying the categories in the Approach to Knowledge Scheme.

The second material, a post-observation interview protocol (see Appendix B), also focused on knowledge, pedagogy, and assessment and consisted of six main questions with

probes such as: Do/did you give assignments that students can answer in different ways? What do you think was the most important concept/principle for students to learn during this lesson? Because the interview took place after the observation, further questions pertaining to the observed lesson were added to focus on particular episodes of the classroom observation. Focusing interview questions on specific episodes of the participant's own teaching was expected to facilitate a more meaningful discussion about the teacher's view of knowledge, pedagogy and assessment.

The third material, Understanding By Design unit plans, (see Appendix C) was obtained by the research prior to the pre-observation interview. Each of the four participants selected one unit plan that corresponded with the content presented during the observation.

The fourth material is an adapted (Keefer & Ruffus, 2003) Approach to Knowledge Scheme (Bereiter & Scardamalia, 1996) (see Table 2). Keefer & Ruffus, 2004, first used the Scheme with teachers. Ruffus-Doerr et al., 2007 also tested this tool with teachers and have begun to standardize coding procedures. The ideas presented in Approach I and Approach II of the Scheme are similar to those outlined by Bloom (1956), Webb (1999), Anderson and Krathwohl (2001) and Marzano (2001) and are generally accepted areas of education. Approach III, however, with its three embedded levels (level 5, 6 and 7), focuses on many of the ideas presented in Knowledge Building, a theory that is not well known in education. If a person is operating at Level 5, knowledge as improvable personal artifacts, they view themselves as constructors of knowledge and responsible for their own knowledge advancement (epistemic agency). A person functioning at Level 6 understands that knowledge is something that can be debated, criticized and improved (improvable ideas and idea diversity) and that is an improvable artifact. The final level of Approach III is Level 7, knowledge as semi-autonomous artifacts.

When participants are functioning at this level they understand knowledge in terms of independent knowledge objects that can be judged, manipulated and improved (conceptual artifact).

Bereiter and Scardamalia's original Scheme was applied only to students and focused on knowledge. The adaptation by Keefer and Ruffus (2004) expanded on Bereiter and Scardamalia's work by applying it to a different population, teachers. In addition, they expanded the topics to include teaching, curriculum, and assessment as well as knowledge and used the scheme to code teacher interviews. Ruffus-Doerr et. al (2007) further refined the categories and standardized the coding process. This adapted scheme, in Approach III, provided categorization and descriptions of how the tenets (epistemic agency, improvable ideas, idea diversity and conceptual artifacts) of Knowledge Building could be understood from a teacher's perspective.

Data Collection Procedures

Three forms of data (interviews, observation, and unit plans) were collected to facilitate data triangulation and increase validity (Yin, 2003). When deciding what types of data to collect, it was important to use data sources that compensated for each other's weaknesses. Because interviews allowed participants to discuss their beliefs in depth they were deemed sources for collecting codable data for this scheme. However, interviews are only "accounts" of practice and true practice is only accessible through observation (Flick, 2002). So while interviews offer an opportunity to have an in-depth conversation about content knowledge and pedagogy, the observations allowed the researcher direct access to the practice. Unit plans of each of the four teachers were important data points to collect because those unit plans clarify the specific goals of each teacher. They also provide a clear description of each lesson and a detailed sequence of instruction. Accordingly they provide a necessary base for placing the

proper context to the other two components of the data: the interviews and the observation.

Before any data collection began, participants were given an informed consent form to read and sign. The form was explained to the participant by the researcher, stating the purpose of the research, the four components, (two interviews, one observation, and a copy of the lesson/unit plan) and the estimated time (approximately one hour each interview and observation). Once the participant was informed and understood the purpose of the study, each participant always had the option of continuing or discontinuing participation in the research at any time during the project. While there were no foreseeable human subject concerns, the participants were given the researcher's complete contact information so that they could contact the researcher should any concerns arise at any time during the study.

Data collection consisted of 4 steps:

(1) a unit plan.

(2) a pre-observation semi-structured interview based on guidelines from Keefer and Ruffus (2004)

(3) an observation of the teacher in a classroom setting

(4) a post-observation semi-structured interview

The unit plan was chosen by the participant and corresponded to the content that was covered in the interviews and observation.

Each tape-recorded interview took approximately one hour. At the beginning of the first interview, the participant was informed of the intended length of the interview (i.e., one hour) and given a brief overview of the interview questions and purpose of the research. The researcher then invited participants to ask questions regarding how the interview would proceed.

After the first interview, the researcher and the interview participant reviewed the participants' daily lesson plans to determine which class period would be most beneficial for observation. The third step, the observation, was audio recorded and the researcher made notes on classroom activity relating to the two research questions. Each observation was approximately one hour and was tape-recorded to help stimulate recall for the researcher and participant during the post-observation interview.

The fourth component of the study was a post-observation interview. As the interview began, the participant was reminded of the intended length of the interview and was provided an overview of the questions. The participant was asked if he/she had any questions before the interview proceeded.

Data Analysis

Thematic analysis was used to address the first research question, "What are teachers' epistemological beliefs and pedagogical practices in a problem based learning environment?" and was applied to the unit plan, the pre-interview, and the post-interview data. Thematic analysis is a classic inductive way to analyze textual data where the themes emerge from the data. The researcher used Aronson's (1994) guidelines for this data analysis. The elements of analysis consisted of "stories" of participating PBL teachers. Each time the teacher changed topics it was the ending of the previous "story" and the beginning of the next "story". For example, a teacher may talk at length about a unit where students are required to demonstrate an understanding of area, angles, perimeter, and volume by creating a to scale blueprint for a playground. This one continuous thought process or plotline was considered one story. Once the teacher changed topics, from a discussion of blueprints to a discussion of a unit on fractions, then that was considered the end of one story. From these stories ideas or themes were listed by

paraphrasing the idea behind each story. The researcher then went back to the data and looked for all the stories that related to the emergent themes. Once themes were established, the researcher checked all three different types of data, (unit plan, interviews and observation) for an articulation of these themes and noted any continuity or omission in the different data sources. When all the stories for each theme were identified, the researcher used these themes and the examples of them to formulate a storyline to address the question, "What are teachers' epistemological beliefs and pedagogical practices in a Problem Based Learning Environment?"

Content analysis (Mayring, 2000) of the data was used to address research the second research question, "Is the Approach to Knowledge Scheme an applicable tool to use with teachers and how can it be further modified to better reflect the ideas of the Knowledge Age?" The pre- and post-interview and unit plans were transcribed verbatim and all teacher utterances were coded according to the preliminary protocol established by Ruffus-Doerr, et al. (2007) using content analysis with deductive category application (Mayring, 2000). In this type of content analysis, data is brought to preexisting categories that contain definitions, examples and coding rules**.**

Content analysis refers to any general text analysis and is a classical way to analyze text material in relationship to an objective coding scheme (Berg, 2004; Flick, 2002; Schwandt, 2001). This method often uses categories, derived from theoretical models, to understand the textual data. During content analysis, the predetermined categories and materials are tested and adjusted when necessary, based on the information obtained from the textual data. The unit plan, pre-observation interviews, observation, and post-observation interviews were analyzed in relationship to the Approach to Knowledge Scheme. The focus was on Approach III.

Content analysis allowed an analysis of data in relation to the Approach to Knowledge Scheme. The investigator expected this method to facilitate the development of a new epistemology for the Knowledge Age. Content analysis was also useful for this study because a major component of content analysis consists of the use of incoming data to adjust the theoretical model and objective scheme, another goal of this research.

For the purpose of this study, the following guidelines directed the process of content analysis**.** One codable unit was one sentence. Each level of the modified Approach to Knowledge Scheme consisted of an operational definition, an exemplary quote, and key words. Using these guidelines, the researcher then decided the category of best fit for that particular utterance. If an utterance had more than one theme expressed, the utterance coded at the highest theme.

To determine the category of best fit, the researcher looked for a theme in the sentence and found the corresponding category in the Approach to Knowledge Scheme. For example when a teacher is questioned about how she knows when a student is knowledgeable about oceans, he/she may respond: when the student knows factual information about specific organisms in the ocean or can cite major sources of ocean pollution (see Table 2 in Chapter 2). The idea in this response is that students are knowledgeable when they can list factual information, which corresponds to Approach I, Level 2, knowledge as a list or set of sortable items. The utterance would be coded at that level.

Another teacher might respond to the same question by saying, **"**The study of mathematics gives you the words and the tools so that you can communicate what you see happening in a situation…" (see Table 2) (Keefer & Ruffus, 2004). The theme revealed in this quote is that when students are knowledgeable in mathematics they understand it as a tool to help

them better communicate their ideas. This quote demonstrates how knowledge is something that can be communicated and shared with others, which corresponds to Approach II, Level 3 and would be coded as such. By coding each unit according to the categories in the Approach to Knowledge Scheme, the teacher's view of knowledge can be categorized.

Mayring's (2000) guidelines were applied in this research. In accordance with his guidelines, after 40% of the data was coded, any modifications deemed necessary were made to the Approach to Knowledge Scheme. During the coding process the researcher made theoretical notes concerning changes in the Scheme, items that are not codable, and patterns in the data. When necessary the researcher went back and re-coded according to the changes and new protocol**.**

Chapter 4

Teachers' Epistemological beliefs and Pedagogical practices

The purpose of the present study is to investigate what epistemological beliefs and pedagogical practices are associated with educating students to become Knowledge Workers in the new Knowledge Age. We are moving from the Industrial Age to the Knowledge Age and this shift has had a fundamental impact on how we work, what jobs are valuable, and even how we should educate our students. Business literature suggests we need a new conception of education if we expect to be successful in preparing students for the Knowledge Age.

So what are the characteristics of these new knowledge workers? Knowledge workers, a termed first coined by Peter Drucker (1959), are people who work with and improve knowledge. Further, researchers (Garrick & Clegg, 2000; Pyoria, 2005; Rodriguez, 2006; Scarbrough, 1999; Syed, 1998) state that knowledge workers can be described as: highly flexible, educated, having specialized knowledge, and working extensively in groups.

The business literature offers a commonsense epistemology for knowledge work based on observation and economic trends. However, these changes suggest a deeper shift in our epistemological beliefs than the business literature would lead us to believe. This shift from the Industrial to the Knowledge Age causes us to rethink not only how we educate our students, but also our conception of knowledge, learning, and the mind.

The standard model of education today still aligns coherently with the beliefs of the Industrial Age, where Knowledge is conceived of as a "body of truths" or a "justified belief". The goal of education then and for some, even now, was to get that "body of truth" into the

minds of students. The question today then becomes, "Does education have a different theory, one relevant to teaching students in the Knowledge Age?" Sociocultural theory addresses many relevant aspects of the Knowledge Age. Most importantly it takes knowledge out of the individual mind and into the community of practice. It also points to the idea that group work is not only necessary because of various areas of expertise among members, but that group work is important because learning exists in social practice. I have suggested that what sociocultural theory does not address quite as well, are the ideas of knowledge improvement and knowledge objectification.

Further, I have suggested Marlene Scardamalia and Carl Bereiter, along with their colleagues at IKIT, do offer a more comprehensive theory, the theory of Knowledge Building that addresses issues humankind will face in the Knowledge Age. Knowledge Building is the continual improvement of ideas through the use of conceptual artifacts. Scardamalia (2002) has suggested 12 principles of knowledge building. Current business literature only addresses five of these 12 principles as being the foundation for knowledge building. These five principles in common are: improvable ideas, idea diversity, epistemic agency, constructive use of authoritative sources, and knowledge building discourse.

Based on a review of the related education and business literature this study was designed to address the following questions:

1.) What are teachers' epistemological beliefs and pedagogical practices in a PBL setting?
2.) Is the Approach to Knowledge Scheme an applicable tool to use with teachers and how can it be further modified to better reflect the ideas of the Knowledge Age

The first research question will be addressed and answered in this chapter, Chapter 4. The second research question will be addressed in Chapter 5.

This study was a collective case study (Berg 2004;Stake, 1994) involving four participants. Three forms of data were used to increase study validity: unit plans, interviews, and observations. For the first research question, this study followed the guidelines for thematic analysis established by Aronson (1994).

The results for the first research question will be presented in two parts. The first part will address two Science participants, Betty and Carl, and present themes that emerged from their data: patterns and connections, Science is about asking questions to help learn about the world, and Science is constantly changing. These three themes were present in both of the participants unit plans, pre-observation interviews, and post-observation interviews. One theme, Science deals with current issues that affect people, was present in only Carl's data and was prominent in his unit plan and interviews. The second part of the chapter will present the themes of two English/Communication Arts teachers, Mel and Drew. One theme, "language is alive" was unique to Mel's data and was only articulated in his pre-observation interview and his post-observation interview. Both teachers discussed extensively the other two themes: creating real readers, and creating real writers, in their unit plans, pre-observation interviews, and post-observation interviews. While the observations* were not coded, the researcher did notice a general continuity from the teachers' comments in the unit plans and interviews, to how the teachers conducted themselves in the classroom during the observation. Under each theme I present and then discuss the "stories" of each teacher that aligned with the corresponding theme.

Science Participants

The first Science participant, Betty (a pseudonym), is a Caucasian female in her 40s. She is a middle school Science teacher of 18 years and has a master's degree in Science

* Please see Chapter 6, limitations section, for further details on the omission of the observation in coding

education. For the past six years she has taught in her current district and she previously worked at a state botanical society. She is a member of her school's behavior and home school visits committee.

Inside Betty's classroom, students sat around five round tables, four to six students to a table. A line of laptops made up the computer station on the right side of the room. Betty's classroom was "decorated" with Science experiments: super-positioning layering grids which aided in the measure of the relative age of rocks and fossils; lava lamps demonstrated the physics of convection currents; and various aquariums housed an assortment of plant and animal life. Student projects were hung on the walls and scattered throughout bookshelves and tables.

Betty did not have a desk but rather, sat at a podium in the front right of the classroom. The podium contained her laptop, student papers, and assignments. Betty stood at the podium in the front corner of the classroom, where she operated her laptop. She kept student papers and assignments nearby. Her slight frame of five foot two inches disguised a no-nonsense attitude towards her students and visitors. She was constantly shooing students away during our after-hours meetings. During the observation, it initially seemed to this researcher that the class may have been "out of control", with students coming in and out of the class at random. Students at different tables were working on different projects (glade unit, earth rocks unit) and were coming in and out of the classroom. Upon further observation, the researcher realized students were going to other teachers' classrooms and the computer lab to ask questions, and research topics, to help with their assignments in Betty's class. The majority of the questions asked of Betty concerned definitions, assignment structure, and clarity. She rarely answered the children directly, preferring to prompt them with her own question, or to direct them to an assignment sheet or an outside resource, such as their peers or the Internet. Throughout this time as she

nudged students one way or another, guiding them in the right direction, she appeared more than anything else to be "directing traffic".

The second Science participant, Carl (a pseudonym), is a Caucasian male high school Science teacher. He is currently a doctoral student in education. Upon meeting Carl, one is immediately struck by his genuine and encompassing love of Science. Along with the responsibilities of his full time teaching job, Carl also served as the district and city professional development representative for "Understanding by Design". Understanding by Design is a framework for teaching, curriculum, and assessment that focuses on teaching for understanding and backward design of curriculum (Wiggins & McTighe, 2005). Carl has established two informal partnerships with a local private and state university, indicating his passion for Science. These partnerships connected him to current research in his field and fueled preparations for his students' in-class work. In addition, his involvement with these schools provided his students with the opportunity to participate in the universities' summer research programs.

His classroom was decorated with large photographs of exotic locations. When asked about the pictures, Carl casually replied, "Oh those are from my trip to the Galapagos Islands". Much like Betty's room, Carl's room housed numerous experiments in various stages of completion.

During the observation, Carl's students, after a brief whole class instructional period, spent most of the class time working on experiments and computer simulations in groups. Carl spent the majority of the time walking around the class and checking up on student progress. Much like Betty's class, the students worked independently of the instructor. But unlike Betty, Carl's students were all working on the same project at the same time and worked more quietly

and never left his room. This gave the impression of a more "orderly" classroom, with students working in groups on the computer, speaking softly about the experiment.

Both Science participants demonstrated various aspects of deep constructivism or Knowledge Building during the data collections process. Four major themes emerged from the unit plan, pre-interview, and post-interview data that might be helpful in articulating an understanding relevant for Knowledge Age teachers. Theses themes were: Patterns and Connections; Science is about asking questions to help learn about the world; Science deals with current issues that affect people; Science is constantly changing.

Science Thematic Category #1: Patterns and Connections. One emergent theme throughout both of the Science teachers' data was understanding patterns/connections in the world and make interdisciplinary and cross-disciplinary connections between those ideas. It was clear that the two teachers shared a common goal. Each teacher wanted their students to transfer knowledge within Science and they also wanted their students to transfer knowledge gained in the science classroom to other disciplines in their curriculum. Betty's utterances focused on students having a deep conceptual understanding of the topic in order to see connections. Carl, on the other hand, demonstrated the need to understand connections in a "systems" approach to teaching Science. The systems approach is based on the ideas that the best way to understand Science is through an interdisciplinary focus on the complex systems in all areas of Science (and society). Carl believed viewing Science through this "systems" approach facilitated an understanding of, "…how something on a really small level can affect somethin' on a very large level".

Betty also pushed the idea of connections in her classroom. Betty believed that for students to transfer knowledge from one area of science to another area of a seemingly unrelated discipline, they should have a deep understanding of the topics involved. In order for her

students to understand the connection between two seemingly unconnected ideas, such as simple machines and astronomy, and be able to transfer that knowledge from one topic to the other, Betty believed students should have a deep understanding of the principles of simple machines and astronomy. If her students could use knowledge learned from the study of gravity on a pulley or friction on a lever in their study of astronomy and orbiting masses, her students would be demonstrating a valuable connectivity of concepts presented in two seemingly unconnected disciplines. When students applied learned principles of momentum and trajectory from a simple-machines unit to one of astronomy, they were seeing connections and functioning at a deep level of understanding. When Betty was asked about deep understandings and Enduring Understandings of Science she offered

> … everything is connected. You can't learn chemistry without biology, or physics, or Environmental Science, or Earth Sciences. Its all connected … if you're going to teach the human body [you need to teach it] with Biology, with Physics with the Chemistry--how your muscles work, how your digestive system processes all this how your blood, the chemistry moves it around …

For Betty's students to understand that everything in Science is connected, she believed they needed to have a deep understanding of Physics, Biology, Chemistry and the Environmental Sciences. It is easy for Betty to see the core principles of Science interacting because she has a deep, conceptual understanding of Science. For example, behind her understanding of the muscular system lie principles of chemistry, physiology, nutrition and biology. By looking for inter-related principles in her students' work, she reinforces her assertion that a complex understanding of any system involves interdisciplinary connectivity. While developing a conceptual understanding of multiple scientific principles was unlikely for a middle school

student, this was Betty's epistemological belief about Science - it was all connected and related. Because of this belief, Betty designed her units to facilitate discussion of topics across many sub areas of Science. As this was quite an ambitious charge, the researcher asked her what would she look for if she wanted to confirm that her students understood the connections in Science,

> If we did a unit, let's say we're doing Astronomy … and something comes up … about gravity and one of the kids goes 'didn't we do something with gravity when we were working with simple machines?' … so … they would make the connection between the units.

By hearing her students vocalize an indirect relationship between these two units, she felt more confident that her students understood the inter-connections between multiple areas of Science.

Betty stressed the idea of Patterns and Connections in her Astronomy unit because, "… the whole point of astronomy is about patterns … it's really based on the patterns of the sun, moon, and earth and how those patterns are connected to each other… ". To help assist the concept of connections and patterns in the Astronomy unit Betty used the cooperative learning technique of JIGSAW (Aronson & Patnoe, 1997) with the students in the "expert" groups focusing on the sun, moon, and earth.

> So if you if we're the moon group, we'll spend a week researching different patterns in the moon. … [and] we'll go back to our home group and say 'ok here are the patterns of the moon' … [then] they will create … an interlinking web that's gonna link all the patterns together [of the sun, moon and earth]

Betty had her students make use of interlinking webs and SMARTboard (an interactive, multimedia whiteboard) to demonstrate their understandings of the relationships and connections between the earth, sun, and moon. If the students could accurately and concretely portray the

relationships, she knew that the students were at least beginning to actually understand the impact that these celestial bodies had on each other.

Betty's trends toward connections showed up once again in her "Earth Rocks" unit that explored the concept of convection currents. The importance of connections was expressed in the Enduring Understanding, "There are internal processes that cause changes in Earth's crustal plates" which was further focused by her Essential Question, "How do the Earth's systems interact?" Betty hoped that students realize that convection currents are the driving force behind a lot of earth processes. Betty went on to explain that she believed her students truly understand the connection between convection currents and the movement of tectonic plates, which result in earthquakes and the creation of volcanoes and mountains. These are currents caused are by materials heating up and expanding upward while cooler and more dense material sink. Convection currents are the driving force behind changing weather conditions and the concept of the jet stream. Similarly, they are the driving force behind the lava lamp, a prop she uses for every "Earth Rocks" unit. When Betty left the weather unit and went onto another unit covering the movement of tectonic plates, her students recognized the same principles in effect concerning the movement of land - not just air. Betty felt her students made a connection in Science that demonstrated they truly understood the principle of convection currents.

Carl's focus on the systems level promoting connections was evident in his Enduring Understanding for his entire course. In the Understanding by Design framework each unit must have an Enduring Understanding, which summarizes the core ideas of the discipline, as well summarize what a student should understand at the end of a unit. Carl's Enduring Understanding for the course was, "Life functions as a complex system that exists at many different levels". This "systems level" understanding of Science really emphasized the connections between ideas

and units of study. Carl believed the integration of the different areas of Science (Genetics, Biology, Physics) was integral to truly understanding Science. Carl also attempted to instill this concept by constantly referring to the connection between what they are studying now, and what they studied in previous units**.**

This theme was highlighted within individual units by demonstrating the patterns and connections found within Science through classifications like "what is a species?" He pressed his students to think about "What kinds of patterns can be observed in a changing world?" This was especially evident when he taught reproduction or as Carl told his students to pique their interests, " … today we are talking about sex … ". In one particular lesson students participated in live and computer-generated simulation guppy labs to see the connection or pattern of the "dynamic interplay between being eaten in your environment, … being camouflaged and being able to blend in and being able to attract a mate successfully". The students ran a simulated guppy lab through ten generations where they controlled the colorfulness of their guppies, the type of environment and the existence of predators. Carl hoped that through this lab the students would see the pattern of mate selection and importance of blending into the environment.

One topic where he stressed a systems approach to Science was water quality. In this unit, he demonstrated to his students how components of a massive interrelated ecology work together and cause change from one area to another. From Carl's perspective, water quality was not a specific discrete problem, but an issue that was related to all the components in the overall interrelated ecological system. Therefore a change in one area was going to impact all other areas of the ecological system. By studying the whole, Carl hoped his students would better understand the connections between the smaller components.

Another topic Carl discussed with his students that exemplified connections in Science was the influence of the pesticide DDT. DDT greatly impacted the eagle population, whose eggshells were so thinned by the chemical that the eagles would often break them by sitting on them. Carl pressed the idea of connections by helping his students to see the interconnectivity of an ecological system through this example. The release of this pesticide into the water tainted the water supply of the eagles, which caused the thinning of the shells, which made the shells less durable, which caused eggs to be broken before the baby eagles were developed enough to survive. This topic demonstrated the chain reaction and impact of one small change. Carl used this example to impress upon his students that Science was a series of complex systems interacting. If his students viewed this particular issue, and Science in general, from the systems perspective, and saw the complex connections across systems, Carl believed they would have a much deeper understanding of Science.

Science Thematic Category #2: Science is about asking questions to help learn about the world. In this thematic category both Science participants were once again addressing the same basic idea and verbalizing it in slightly different ways. Both Betty and Carl focused on getting students to understand that Science is about asking questions and finding systematic ways of answering those questions. While Betty focused on the curiosity aspect of Science, Carl took it a step further and discussed wanting students to know that asking questions about Science helped students make inferences so they could better understand the world.

When Betty was asked what a student would know after developing a love for Science, she replied,

> For me Science is about … always asking questions … if you don't know something don't take it at face value that you don't know it, want to find out what the answer is …

> for me that turns into experiments … I wonder if and it's always that wonder if … so for them to always question to be curious enough to want to find the answers … to me is what Science is about

For Betty this curiosity could be implemented through the use of uncanned labs. She believed the freedom in these uncanned labs, which do not have a prescribe series of steps to follow, but rather allows students to choose what variables to manipulate by asking their own questions and creating experiments based on their observations, would pique their curiosity. One of these uncanned labs, the crayon experiment (sometimes called sinkers and floaters), focused on the concepts of density and buoyancy. Buckets were filled with water and crayons and students were instructed, without specific background information or detail, to "fiddle with" and manipulate the arrangement, questioning amongst themselves. After watching them closely, she asked them the next day what they had learned on their own:

> I heard you guys talking um and some of you thought they were floating or sinking because of this how would we find that out? So then they set up their own experiments and then one or two people were researching while the others were doing it and figuring out why

While the "answers" of density and buoyancy are fairly clearly established in Science, Betty was attempting to create curiosity in her classroom by allowing students the freedom to explore their own ideas in this uncanned lab. Although the results of the uncanned labs should be in line with results from a traditional lab, with detailed step-by-step instructions, Betty attempted to plant a sense of curiosity in her students through freedom in these uncanned labs. This curiosity was integral to the study, and her love, of Science.

When Carl was asked about the importance of Science he stated … "I want kids to not just understand that Science is a bunch a facts [but to understand] that Science is actually a process of learning about the world". He probed with questions like: How do scientists work and how do scientists ask questions? For Carl the answer to these questions from a scientific perspective was reflective questioning because

> … Science is a process of experience and learning by asking questions and trying to find answers … for the last couple of years is the concept of scientific inference and how scientists … can make observations through testing … they take observations and prior knowledge and then make inferences from those things

As he explained, this is a different perspective than teaching the scientific method. He felt it was important for students to understand the link between prior knowledge, inference, and repeatable testing because he believed that is how scientists work. He wanted to model this kind of thinking in his own classroom so that his students would have a greater understanding of the world around them. Repeatable testing was an especially important idea for Carl because he wanted his students to understand that they "can't just run a test … kids have to understand we can set up a controlled investigation but it has to be repeatable … ". This repeatable testing is important to Carl because, as in his example of drug tests, reliability is often a matter of safety. One drug that helps one person may actually hurt another. Carl believes the necessary skill of controlling variables and experiment design, will lead students to ascertain more reliable results. Armed with valid scientific information the students can make fully justified inferences about the problems they are attempting to solve in the classroom and the community.

In this category both teachers allowed their students to be in control of solving the problem by allowing them to choose which variables and settings impacted the experiment.

Students made these choices after discussing their thoughts within the group, which also allowed them to hear and use conflicting ideas before they proceeded. By tapping into students' curiosity and by demonstrating how Scientists ask questions, Carl and Betty hoped that students would see that Science is about asking questions to find out about the world.

Science Thematic Category #3: Science deals with current issues that affect people.

Another idea that appeared throughout Carl's data was the idea that Science deals with current issues that affect people. The question he posed to his students was, "How does understanding the living world help us solve our problems?" Students were expected to write a journal entry on this question as a final assessment and Carl hoped they would see problems that affect people could be addressed, and possibly solved, through greater scientific knowledge.

An area where this was particularly relevant in his class was in the genetics unit. To help the genetics unit feel more authentic and relevant to his students, Carl created a program called PERSONAGEN. Through this program he was able to create fake genetic profiles for each student. He passed out the genetic profile, and convinced them that this was their actual genetic profile. After informing his students that these were only fake profiles meant to pique their interests in genetics, the students had to set about analyzing their profile. As a final component, they had to conjecture how their lives might change, based on this new information.

As an assessment for the unit on genetics, Carl had the students prepare for a debate covering the ethical issues related to genetics. The debate included genetic testing, cloning, stem cell research, and DNA Science. By allowing students the opportunity to debate, he hoped his students, like the scientist of today, would " … wrestle with the ethical questions as they relate to genetics and DNA Science". Carl felt this particular unit on genetics helped the students understand how Science impacts their everyday lives.

Science Thematic Category #4: Science is constantly changing. The final theme that emerged from the data for both Science participants was the idea that Science is constantly changing. This takes the form of improvement of current theories as well as all of the ideas Science has yet to discover.

Carl instilled the idea that Science is still evolving by pointing out to his students all the things we still do not know, all the scientific discoveries waiting to happen.

> I am always going off the deep end saying … we're on the cutting edge guys. This is the best time ever to be a biologists because there's so much we don't know … and they'll ask a question and I'll go I don't know you can go to grad school and become the person who figures that out.

The idea that there is so much more about the world to be discovered greatly excited Carl and he attempted to model that excitement and love of Science for his students.

This thematic category also appeared to make Betty the most animated during the interviews. When she was asked if she felt there were clearly correct and incorrect answers in Sciences Betty replied "yes" but qualified, "… I think when you get into the … essential kind of questions … when you get into the big ideas that people will debate forever …" there are no right or wrong answers. She goes on to say what is so "cool" about Science is that it is always self-correcting, based on new information and current research. "So truly what we thought, Pluto is a 9th planet … Well now it isn't a planet … Science is always very willing to change its theories or change what they've said based on new information … that's kind of the nature of the beast."

The idea that Science is always changing and a work in progress, is what Betty and Carl attempted to instill in the students about their own work, about learning, and in assignments as

well. Both participants required revisions of projects and tests by all of the students. In Carl's classroom, after a test was completed and graded, it was mandatory for all students to meet in groups and discuss incorrect answers. For each test, he required his students to resubmit the test along with explanations about why the correct answer is correct, where they went wrong in their own thinking which led them to an incorrect answer.

Betty reinforced improvement to her students through peer and teacher critiques and rebuttal. She readily admitted this process of critique has been, and continues to be, difficult to establish with the students. In the beginning, their comments focused on superficial elements of the project such as background color and font. However, by talking about what types of comments would and would not be helpful to their peers, the content has improved greatly over time.

To help the students think about critiques on a deeper level, Betty asked her students to consider, "How might we critique this so they get positive feedback that helps them make a better project?" She emphasized that these critiques were still simply the opinions of other students. In the final stage of the critiquing process students were allowed a written rebuttal to their peers' critiques. One technique Betty used to develop this understanding in her students was a "stay and stray". In a "stay and stray" one student stays at the table to present the group's work while the other students "stray" to other tables to critique their peers' projects. Each person who strays was given a critiquing sheet and was asked to give positive comments as well as suggest areas for improvement. Considering the middle-school age of her students, Betty was very determined to end the critiques on a positive, constructive note.

Betty also demonstrated the changing nature of Science to her students through her "Earth Rocks" unit. In this unit students "explore the geological history of plate motion and how

it has affected the surface of the Earth. From Pangaea to the present, students "gain an understanding of the power of Earth's processes". The main questions that guided students in this unit were: "How do convection currents create mountains? How can we determine the past geological history of the Earth? How do the Earth's systems interact?" In this unit students learned about rocks and their classifications, convection currents, mineral deposits, fossils, dating, plate tectonics, and geological features. In the culminating assessment students were asked to revamp the Earth Science unit and propose a new and completed chapter in the textbook to make it more current. While Betty did not exactly expect her students to create "publishable" chapters, this assignment did reinforce the idea that Science is evolving enough or changing enough to justify updating students' textbooks, which excited Betty. She said that, "English you could drag out the same grammar book from 50 years ago [and] they are still using the same rules". Comparatively, Science texts are constantly out-of-date.

English/Communication Arts Participants

The first Communication Arts participant, Mel (a pseudonym), is a Caucasian, male, middle school Communication Arts teacher who holds a master's degree in English linguistics. He has taught for over 12 years, the most recent three within his current district. Before moving to this school, Mel taught middle and high school English in the Northeastern United States. As an undergraduate, Mel spent a semester abroad studying at Oxford University in England.

Mel's room was spacious, organized and uncluttered The entire back wall was covered in slang terms and other "words" that turned out to be the new slang creation of Mel's students'. The other three walls were either windows or clear glass panes. The desks were arranged in pods of four. During the first interview, all of the bulletin boards were covered because standardized testing was taken place.

Much like the other participants, Mel's classroom is seemingly chaotic with a constant flow of students coming in and out of the classroom. Each group of students is working on different projects and in various stages of each project, coming in and out of the classroom. While Mel acknowledged he does plan more structured and traditional class periods, once the students begin the project portion of each unit it can look chaotic to an observer.

The second English participant, Drew (a pseudonym), is a Caucasian, male, high school English teacher with a master's degree in English education. He has 17 years of teaching experience, working the past six years at his current district. He is around six feet tall with long hair always pulled back into a ponytail and a booming voice. Drew is the head of the English department, and serves on numerous committees, including mentoring committee and teaching and learning committee at his school. He is a pedagogical specialist in reading and writing and currently serves as the faculty advisor for the student literary magazine.

Upon entering Drew's classroom, the reading area immediately to the left stood out as most unusual. The left side of the room is complete with an electric fireplace, four leather chairs, a Persian rug and two bookcases enclosed in glass while on the right side of the room, a more traditional setup hosted students with a whiteboard and a computer. The tables were set up in a large square that seats about 15 to 20 students at a time.

Much like Betty's Science class, students in Drew's class appeared to be coming and going at random and wandering around the classroom, based on their own interests. However, closer observations revealed students taking part in English-related activities. During a class reading of a short story, students appeared to be off-task and wandering around the room without paying attention to the teacher, but many of the students were picking up books and reading them and discussing readings with each other.

English Thematic Category #1: Language is alive. One theme present in Mel's data was that language is alive and changing. This theme was unique to Mel. The cultural disconnect with his minority students, especially regarding language, was a challenge for this middle school Communication Arts teacher. To help create opportunities for every student, Mel explored the difference between "academic" language and "friend" language used in everyday conversations. Mel wanted his students to understand that academic English was not the only correct and effective way to communicate. It was important for them to be able to differentiate between the appropriate uses of each. The important concept, for Mel, lies within "…the situation that dictates how to communicate". Mel was able to convey a changing English language to his students by looking at the different types of verbal communication, slang, dialect, jargon, and "lingo". He wanted his students to recognize the subtle nuances that dictate what is the appropriate "language" to use. When Mel observed his students using appropriate academic or friend language in multiple instances, he felt that they truly understood that language was evolving. He played with this concept by asking his students to " … make up a slang word and start using it and see if it catches on … So the point was for them to see how language is adapted and changes and functions … which words worked well and which words don't." For Mel the focus on slang demonstrated that slang could be an effective and situationally appropriate way to communicate.

English Thematic Category #2: Creating real readers. Creating real readers was a theme that emerged in the interview, and unit plans with Drew and Mel. When asked what his goal was for his students, Mel responded that he wanted them to develop, "a love of reading …". Mel and Drew both found the traditional classroom a challenging environment to foster a sustained interest in reading. They both felt it [traditional classroom] does not make explicit why one

reads, nor does it allow students to read at their own ability level. Drew especially discussed how he dealt with a great variation of reading ability because he had the challenge of students who were reading at the third grade level through the college level. He felt to create a love a reading he first needed to create an environment where students could read at the appropriate level of challenge within a topic that interests them. His solution to this problem was to use book clubs. In a more traditional classroom, every student read the same book at the same time, but Drew wanted to keep "… in mind how real readers choose texts. How and why they read them …." As a student, he found whole-class-assigned readings difficult; as a teacher, it created even more challenges

> I don't do any whole class novels anymore. Last year was the first year that I completely stopped. The year before I did *1984* … and it was like so much fakery of reading. Boy I've never seen so much energy going into fake reading and I thought boy this is silly to be faking reading.

Drew allowed student choice of subject, genre and pacing with book clubs to overcome this obstacle. Hel also believed these choices were critical to help create "real" readers and to develop students' love of reading.

> By real I mean I'm reading this book because I want to read this book not because my teacher assigned it. I'm interested in it. I'm reading a novel because I'm interested and I'm gonna go to my … book club I'm a part of next week and we're gonna sit around and drink wine and talk about it… or you're a high school student [and] you're in the cafeteria, [and] people are … talking about this book Big Mouth Ugly Girl and they're having a ball talking about this book and that makes me want to read this book …

Mel also focused on helping stimulate a genuine interest in reading by creating book clubs. He attempted to instill interest by integrating a multitude of genres and establishing an environment of self-motivated, "real readers" through book clubs and literature circles.

The literature circle choices for this particular unit included, *Red Scarf Girl, Zlata's Diary, Katarina, Maus 1 and 2, The Diary of Anne Frank,* and *Among the Hidden.* Students from the entire grade level took part in literature circles during the last period of the day. Students were given "tickets" to classrooms that hosted different literature circles and chose which class to join based on the book being explored. This hopefully raised student interest in reading since they weren't forced to participate in a reading circle involving a book in which the student had no initial interest. Teachers were allowed to offer a large variety of books to their students rather than each classroom only getting to read and discuss a single book. Mel believed choice alone played a big role in fostering a love of reading and helped model how real readers choose and discuss books. Within the literature circles, students were assigned one of five roles that were meant to help ease the flow of conversations. However, Mel found it unnecessary, as the students were able to discuss the books for extended periods of time. Since the students attended the sessions well prepared they were able to, "… just sort of talked about it [the book]".

The literature circles also enabled Mel to instill in his students that literature is debatable. "Most of the things that I have them do when we're reading is what did you think about and why? What would you do? And then when we have a discussion, a lit circle, then we get to share opinions". Through the literature circles students could see competing interpretations of a text.

Mel acknowledged that it took a lot of modeling and scaffolding to get the students to the point of independently discussing a book for 45 minutes with no teacher involvement.

> We looked at lots of examples. There are some standard questions that the leader … [offers] 'what did you think about the book?' We talked about which questions would be good to start with, which would generate other ones. And I said come prepared with twenty questions just in case.

The first literature circles were only ten minutes in length, and students hesitated to converse on their own. Mel found as he:

> … walked from room to room, … there wasn't one group that wasn't actually talking about the book … for 45 minutes. They were able to keep a conversation going about the book…" And they started with deep - I'll call it deep specific. They understood what I wanted when I said deep, … but they were very specific instances in the book. Because that's … what they're connecting to. There weren't necessarily broad sort of literary questions.

Like Mel, Drew used literature circles (book clubs) to help create real readers. Because Drew's students were older, he was able to use less scaffolding than Mel to get the groups to work productively. The maturity of the students in Drew's class also allowed them to discuss more complex ideas of genre and literary techniques during the literature circles instead of just the who, what, when, where and why of the book.

> The book clubs consist of four self selected students who choose the books and agree on the timeline. One book from each given genre is required. For the timeline the students must agree on how many pages they will read per night and how long they have to read and discuss each book. This is decided by the students but must be discussed with the teacher for final approval. The students alternately choose from the roles of Connector, Questioner, Literary Luminary, Illustrator, Summarizer, and Word Wizard and rotate

roles. It is up to the group and the individual student to make sure they are on schedule and allow sufficient time to read an example.

Throughout the semester students got to choose their own books, what they wrote about, and when they turned in the assignments. It was only required that they read one book from each of the highlighted genres and that they write an original work in that style. While reading pieces from the different genres, Drew wanted his students to ask the questions, "How does an author 'mean'? and "How do literary devices cause a work to achieve its affect?"

> so I spend a lot of time with the concept of genre and genre is really a lot about determining what you want to say and determining the audience that you have and then saying how can I best express that? … they've got an idea of saying here's my desired purpose here's what I am trying to express here's my audience what do I need to make that exchange successful?

Drew wanted his students to understand that "reading is social" and he liked seeing students choose books based on recommendations from other students because, "that's what real readers do, right?" In the "real" world books become popular thorough social networks, conversations at lunch and dinner, and even the recommendations of TV personalities. It did not surprise Drew that certain books emerged as popular with students through social networking and conversations over lunch. Drew was pleased and felt that his students were becoming active readers who enjoyed books.

English Thematic category #3: Creating real writers. Another theme that developed in both teachers' classrooms was how to create real writers out of their students. For both of these teachers, real writing means understanding the connection between reading and writing. Writing

is a cyclical process and needs to be "public". This level of public writing ranged from posting in the classroom to publishing work in national student competitions.

Both instructors strived to teach their students techniques to improve writing and promoted the idea that reading helps create ideas for writing. One of the Enduring Understandings of Mel's unit is, "reading gives you good ideas for writing". "A lot of kids say 'why are we reading this?' Because it will help generate ideas for writing … we read for enjoyment but reading [helps us] to get ideas …". An example of this in Mel's classroom is the *Whirly Gig* book and the Defining Moments essay. The book *Whirly Gig* by Matt Berman is about a junior high student, Brent, who succumbs to peer pressure and gets drunk and on the way home. Brent tries to commit suicide but ends up killing an innocent person in a car accident. Following the incident, Brent embarks on a journey of self-discovery. Mel chose the book in part because he wanted to challenge his students with a non-linear plot, he also wanted his students to connect the idea of the book to the defining moments essay:

> Now as they're writing the essay I'm perpetually referring back to the book. It's helping to make a connection between writing and the real world, because I don't want them to see writing as something they have to do in the school and then they're done

Mel assigned *Whirly Gig*, because he wanted his students to generate ideas for their own Defining Moments essay. In this piece of writing, students examined what moments changed their lives while considering certain stylistic techniques meant to persuade and engage. Mel hoped that their essays become more interesting as a result.

Throughout the semester Drew allowed his students extensive freedom by letting them decide: book choice, paper topic and assignments due dates. Drew required that his students read one book from each of the highlighted genres and write an original work for each genre.

While reading pieces from the different genres, Drew wanted his students to ask the questions, "How do literary devices cause a work to achieve its affect?" Drew believed this question would help his students learn how to use literary devices effectively, which would in turn improve their own writing. Drew used genre studies to strengthen the link between reading and writing. The students were expected to write essays based on ideas in their seed journals for the following genres: personal narrative, short story, poetry, informational essay, expository essay, and a genre of choice. In the genre of choice he found most students write reviews or letters and he keeps a list of optional genres that the students can pursue, " … hopefully it's rising out of a genuine interest in communicating an idea to an audience they've identified". His goal was for his students to be producing a piece of writing for a real audience. To Drew, by writing in a specific style to a known audience, his students imitated how real writers work. He believed that by taking his students through this "tour of genres" and leaving as much up to them as possible (book choice, pacing, and deadlines), and writing to a specific audience, " … by the end of the semester they're hopefully producing real writing for real audiences …".

To help create ideas for writing, Drew had his students' write a few pages every day in a seed idea journal. He hoped that this would create a sense of fluency in his students and would create seed ideas for later use. This journal was not, as he stated, a "dear diary" outlet but rather, a record of any thoughts during the day. Most often he hoped students would write down thoughts as they were reading, but he allowed anything. In his own seed journal after hearing *Material Girl* by Madonna, Drew wrote that he had hated that song until he realized what the lyrics were really saying. When he went back later to his journal this "rant" inspired him to write a full-length essay. What Drew really wanted his students to understand was that ideas can

come from unexpected moments and, no matter how seemingly random they were, writing them down would develop a valuable habit with useful benefits.

A major theme in both English/Communication Arts teachers' data was the creation of real writers, which meant a focus on the cyclical nature of writing. Both teachers utilized workshopping and conferencing on student writing to reinforce the revision component of writing.

During the writing process a student would bring their work to Mel or to another student to receive feedback and suggestions for improvement. Initially, Mel looked for content, gaps, anything that was unclear, tone and voice. It was only toward the final stages of the piece that he addressed proofreading. Even though this process was incredibly time-consuming, Mel saw major differences in quality from draft to draft. The first few drafts were often simply lists of events. After feedback from him and students peers, they were " … talking about sensory images, things they remember, smelling and feeling as opposed to 'I did this …'"

For Drew an important component of creating real writing for real audiences was the drafting and writing conference process as well. He required his students to have at least two conferences per piece, one with him and one with another capable adult, such as another English teacher or a member of the writing center staff. Before each conference, students were required to fill out a form requesting what type of feedback they wanted. The feedback could be as vague as: "…[do] you know what I am trying to say here? What do you think my story is about" or could be as specific as "could you proofread this?" Throughout this process, he tried to instill a common order of priority, "… fluency, clarity, craft and correctness …" when asking for feedback. Aside from improving the quality of the drafts, Drew impressed upon his students that

this was what "actual writers" do. Drew even reminded his students that Stephen King's wife reads all of his manuscripts before they are sent to the publisher.

Drew wanted his students to experience the communication, feedback, and cyclical nature of writing with the use of conferencing. He was also constantly pushing his students to make the connection between reading and writing during the conferences. He might say to a student, " … ok this piece here you're telling me a story about this thing you did Saturday night but I'm not really feeling it. I think you would benefit from adding specific details … ". To help students draw on examples, Drew often asked students to pull out the book they were reading and find a point in the story where the author's use of details or descriptions really helped set a tone or helped the reader empathize with the situation.

He also believed that the repeated nature of revisions was a critical component to creating real writers because, " … for the most part … if you're writing and you're publishing a book you would give it to your editor, the editor would give it back … nothing gets published without it being perfect …". Drew wanted his students to think of their writing as real writing rather than school assignments.

The final element of creating real writers was to create opportunities for students writing to, "… go public at some level …". Students were required to publish a few of their pieces in a school literary magazine, newspaper, or various other journals and contests. He felt publishing their writing was an essential of the writing process, and allowed students to receive feedback and critique on a larger scale.

Summary of Results

When investigating teacher's epistemological beliefs and pedagogical practices, themes by subject matter emerged. In the discussion with the Science teachers themes included

understanding Science as: Patterns and connections, asking questions/learning about the world, and the changing nature of Science and science is current.

English/Communication Arts teachers had relevant discipline related themes that permeated their data set as well. The themes of Language being alive, wanting to create real readers and wanting to create real writers were expressed in different ways throughout the data.

When the Science teachers discussed patterns and connections, they were looking for students to have a deep understanding of Science as well as an understanding of the principles and patterns that are the underpinnings of Science. They believed this would lead students to see connections within multiple Scientific fields as well as fields outside of Science. When the teachers saw the students making these connections, they knew the students saw the knowledge as context-free. That allowed the students to see how the principles of Science would be usable in other contexts, promoting the idea that Science knowledge is usable through an understanding of the connections in Science.

The theme, Science is about asking questions, demonstrated itself when the teachers discussed the importance of creating a sense of curiosity and gave students control over their own learning process. This asking of questions also promoted student discussion, which lead to students hearing other perspectives. By promoting a sense of curiosity about Science, both Betty and Carl hoped their students would see that Science is about asking questions to find out about the world.

Yet another theme that emerged from the Science teachers' data was that Science deals with issues that affect people. In this category the Science teachers wanted their students to discover the question, "How does Science help us understand the world around us?" Through the process of asking questions and asking how Science can help us, both teachers promoted

debate in the classroom. They hoped this debate would help students to a deeper understanding of how they could use Science to help understand the major issues in the world around them.

The final theme that emerged and that created the most animated discussion from the teachers was that, Science is constantly changing. When discussing ideas related to this theme, both teachers focused on wanting their students to understand that Science is always self-correcting and willing to change based on new information. They believe this is different from how most students view Science: a body of facts. The teachers think the changing of nature is what is so exciting about Science and they hope to pass that belief onto their students.

The English teachers also had themes that repeated in their data set. The first theme, only articulated by Mel, was that language is alive. Just like Science, English is also constantly evolving. Mel attempted to demonstrate this through the ideas of "friend" vs. "school" language and the development of slang. To help the students really see that language is evolving Mel asked them to develop slang words and then analyze why one caught on and the other did not. He hoped through this exercise that his students would see that the meaning of words is constantly evolving and that English is also creating new words.

Another theme, expressed by both teachers was to create "real readers" by instilling a love of reading in their students. Both teachers felt the most effective way to create this love in their students was through the use of book clubs. Mel and Drew stated that the book clubs allowed their students to act like real readers. In other words the students would have choice over what books they read, they would debate ideas in the book, and see other perspectives during those debates. They both felt by giving students this type of control and modeling how "real readers" choose and discuss books; they would create a love of reading.

The final theme that emerged was creating real writers, a theme that is related to creating real readers. To create real writers, both teachers wanted their students to understand the connection between reading and writing; that reading gives you ideas and improves your writing. They implemented the use of conferencing/workshopping to demonstrate to their students that writing is a cyclical process, and a written piece can always be improved. The final component of creating real writers was for their students write for a real audience. The teachers reinforced that idea by requiring students to "go public" with their assignments.

The results of this analysis indicate that there are significant epistemological beliefs and pedagogical practices being practiced in the PBL setting that would be useful in educating students to become Knowledge Workers in the new Knowledge Age. Even though they were in very different subject areas, all four teachers demonstrated themes such as improvability of knowledge, and idea diversity, which are helpful in understanding how the needs of the Knowledge Age can be met in education.

Chapter 5

The Approach to Knowledge Scheme: Applicability and Modifications

In Chapter 1 of the present study, after an examination of the research, I proposed that there has been a change in the expectations of the workforce as we move from the Industrial Age to the Knowledge Age and that education will have to be a foundation for this change. I further suggested that this change requires a shift in our understanding of knowledge, learning and the mind. Since education is essential for a successful transition I discussed education's theories of knowledge and suggested that Knowledge Building (Scardamalia & Bereiter, 2003) is the most relevant theory in education to address the needs of workers in the Knowledge Age. Bereiter and Scardamalia (1998) further suggest that the most predominate taxonomy in education, Bloom's taxonomy, does not address the needs of the Knowledge Age and created the Approach to Knowledge Scheme with the intention of the Scheme replacing Bloom's taxonomy. This Scheme can be thought of as levels of knowledge objectification and consists of three Approaches with seven embedded levels. The first two Approaches address ideas presented by Bloom, but Approach III is the extension of Bloom that Bereiter and Scardamalia feel address the needs of the Knowledge Age. Bereiter and Scardamalia (1998) tested this Scheme on students and other researchers (Keefer & Ruffus, 2004) have further refined the scheme and used it to categorize teachers' approaches to knowledge.

To investigate the Knowledge Building theory, I researched teachers' epistemological beliefs and pedagogical practices in a Problem Based Learning (PBL) environment and found relevant themes. The Science teachers understood the importance of Science as: Patterns and

connections, asking questions to learn about the world, dealing with issues that currently affect people, and the fact that science is constantly changing. The English/Communication Arts teachers also had a set of emergent themes: language is alive, creating real readers, and creating real writers.

In this chapter, I address the second research question, " Is the Approach to Knowledge Scheme an applicable tool to use with teachers and how can it be further modified to better reflect the ideas of the Knowledge Age?" The same three forms of data (unit plan, interviews, and observations) that were collected to address the first research question were also used to address the second research question. Content analysis was used to analyze the research question concerning the Approach to Knowledge Scheme (ATKS). For the content analysis, an utterance was considered one sentence. The utterance was compared to the Levels in the Approach to Knowledge Scheme and a category of best fit was found by comparing the theme in the utterance to a theme in the Scheme. Mayring's (2000) guidelines were applied to this data set. After 40% of the data was coded, the researcher realized the need for some modification to the Scheme. Once the modifications were made, the researcher went back and recoded all of the data. The results of the analysis found the ATKS, with some changes, was a relevant tool to use with teachers. The three changes deemed necessary were: additional definitions, inclusion of key terms, and the addition of another level.

The results of the data will be presented in four parts. First, I will discuss the additional definitions to the Scheme and give examples. Second, I will present the inclusion of key terms, define the meaning of each term and provide defending examples. Third, I will discuss the inclusion of a new Level in the Approach to Knowledge Scheme. Finally, for all Levels in

Approach III, I will provide exemplar quotes and defend why the quote should be coded in that level.

Approach to Knowledge Scheme

Utterances for the unit plan, pre-observation, and post-observation interviews were coded according to the protocol described in the methods section. There were a total of 1566 coded utterances at all levels of the Approach to Knowledge Scheme (see Table 3) and 1094 non-codable utterances. The majority of these non-codable comments (865 utterances or 80% of the non-codable utterances) were non-content related comments. The topics that fell under this included: comments on individual learners and their characteristics, finances, socio-economic status, state testing, and school district issues. These utterances were not used in the analysis.

Table 3 Codable Utterances in the Approach to Knowledge Scheme

Approach to Knowledge Scheme (Ruffus Doerr, 2010)	Percentage of codable utterances
Approach I	11%
Level 1 Teacher's approach to knowledge, teaching, curriculum and assessment (KTCA) is oriented toward a view of knowledge as consisting of correct and incorrect facts.	5%
Level 2 Teacher's approach to KTCA is oriented towards knowledge that is list or set of sortable mental content.	6%
Approach II	21%
Level 3 Teachers' approach to knowledge is focused on KTCA that can be represented, interpreted and communicated to others.	8%
Level 4 Teachers' approach to KTCA focuses on the significance of understanding knowledge from different perspectives, which can help the students to a deeper understanding of the problem	13%
Approach III	68%
Level 5 Teachers' approach to knowledge consists of KTCA as personal artifacts.	4%
Level 6	44%

Teachers approach to KTCA is to see themselves and their students as users of knowledge.	
Level 7 Teachers' approach to KTCA is to see themselves and their students as improvers of knowledge.	20%

Of all the 1,567 units of codable data 11%/177 of the utterances were coded at Approach I. Approach I consists of Level 1 and Level 2. Five percent/84 codable utterances were at Level 1 and focused on students understanding knowledge as correct vs. incorrect information, and the importance of students "needing to know" certain facts. Level 2 consisted of 5%/93 codable utterances and teacher comments stressed defining, listing and summarizing. Twenty-one percent/327 of the utterances were coded at Approach II, which consisted of Level 3 and Level 4. Level 3 had 8%/129 codable utterances focused on being able to communicate and share information. Level 4 had 13%/198 codable utterances and focused on discussing topics in order to better understand different perspectives. Sixty eight percent/1063 of the utterances were coded at Approach III, which consisted of, Level 5, Level 6, Level 7 and Level 8*. Utterances coded at Level 5 4%/55 focused on personal construction of ideas. At this level, teachers discussed the importance of students making sense of the content for themselves and of student ownership over learning. The majority of the coded utterances occurred at Level 6 44%/688. Utterances coded at Level 6 focused on teachers seeing themselves and their students as users of knowledge. While there was a variety of topics discussed at this level, the most repeated ideas included: importance of connections (both across and within the discipline), deep understandings of a topic, application of knowledge, and understanding relationships between ideas. Utterances coded at Level 7 20%/306 incorporated improvement of knowledge and student work, acting like

* Approach III now consists of four levels. Further information on the new level can be found in Chapter 5 under the heading New Level in the Approach to Knowledge Scheme

people in the field, putting work into the public discourse, and the flexibility of knowledge as we make new discoveries. Few utterances (0% (.19%); 3) were coded in the final category, Level 8 and focused on the inherent value of the discipline.

The results in this section focus on the main ideas presented in Approach III: knowledge as personal artifact (level 5); knowledge as usable and improvable (level 6); and knowledge as autonomous (level 7); as well as any new categories or modifications made to the scheme as a result of this study. As suggested by Heisch and Shannon (2005), for each level exemplary quotes from the participants were listed as well as a discussion of the quote and descriptive evidence supporting the coding.

After coding the data there was evidence to suggest that the ATKS is an appropriate tool to use with teachers, but some changes were necessary to improve the tool and make it more reliable. During the coding of the data, key terms after each utterance were added to justify or explain why an utterance was coded at a particular level. Once the first 40% of the data was initially coded, the key terms and researcher notes were compiled and sorted for themes. Three major changes were determined to be necessary to make the ATKS a more useful tool (see Table 4). The three changes were: additional definitions, additional key terms, and a conceptual change in the levels of the ATKS. These changes will be fully explained in the following paragraphs.

Additional definitions. To improve consistency in the coding, it was determined that each level needed further definition. Originally each level in the ATKS had a title, "Teachers' approach to KTCA conceptualizes knowledge in terms of personal artifacts" and was followed by examples of teacher utterances coded at that level. Because of the brevity of the title and the ambiguity of many of the ideas presented in that title, further clarification was needed. After the changes,

each level consisted of: level title, definition, key terms and examples. For example, Level 5 originally consisted of, "Teachers' approach to KTCA conceptualizes knowledge in terms of personal artifacts" and had no further clarification. The new description of level 5 includes the original title," Teachers' approach to KTCA conceptualizes knowledge in terms of personal artifacts", as well as the following description: "Teachers' understanding of knowledge consists of knowledge as a personal construction of theories and ideas. Teacher utterances coded at this level focus on teachers' and students' responsibility for generating their own ideas and creating long-term goals for learning. The focus is on a person constructing their own understanding of a situation, building personal theories, or feeling ownership" (see Table 4).

Key Terms. The second change that was made to improve coding consistency was the inclusion of key terms under each level in the ATKS. After each utterance was coded, a key term was added in the data set. These key terms were compiled by level and were included in the ATKS. Upon compilation, it became apparent that some key terms were used in more than one level. While the intention or meaning of the word was different for the different level, the word itself still repeated. For example the term "debate" was found in both Level 4 and Level 7. In a discussion about debates coded at Level 4, the focus was on the importance of students hearing different perspectives. In utterances using the idea of debate coded at level 7, teachers discussed debates as important to help students rethink and revise ideas and projects. While the key term "debate" appears in both levels, it has different meanings and implications. This repetition of apparently identical terms prompted the inclusion of further explanation of terms and how they applied to ideas in a level. In Levels 1-3 no further explanation was necessary because the key terms, such as "define", "list" and "summarize", were clear. However in Levels 4-8 most key terms have further descriptions.

The importance of key terms was especially necessary in Levels 6 and 7 with most of the key terms needing elaboration. For example, in level 7 (improve knowledge; table 4) some of the key terms that needed expansion include: "debate", with the intention that the debate will cause students to rethink and improve ideas/projects; "broaden/expand on previous knowledge/ transfer", take principles of knowledge and apply it to a different situation implies improvement; "what/ifquestioning", recognizes incompleteness and the potential for change and "publish ideas in the broader community", assumes once the idea is published in the public domain, people will critique and improve it. It is hoped that these further descriptions clarify these ideas.

New Level in the Approach to Knowledge Scheme. The conceptual change made to the ATKS was the addition of a new level, changing the ATKS from seven to eight levels (see Table 4).

Table 4 Approach to Knowledge Scheme Comparison and Modifications

Ruffus Doerr (2010)	Keefer & Ruffus (2004)
Approach I	Approach I
Level 1 Teachers' approach to knowledge, teaching, curriculum and assessment (KTCA) is oriented toward a view of knowledge as consisting of correct and incorrect facts. Teachers' understanding of knowledge consists of factual knowledge with correct and incorrect answers. Teacher utterances coded at this level focus on whether or not a person "knows" something. The focus at this level is on defining, reviewing or answering a question. Key Terms/ideas may include: Quantify, Being told, correct vs incorrect, knowing vs not knowing, define, review (e.g., 1) "Communication Arts is a - that's a content class. That's where you learn who Romeo is." (correct vs incorrect) (e.g., 2) "If you want to say what is the wattage of a light	Level 1 "Teacher's approach to knowledge, teaching curriculum and assessment (KTCA) is oriented toward a view of knowledge as consisting of correct and incorrect facts" (Keefer & Ruffus, 2004, p. 5) "Just as in with Boon Meadows they have such a hard time getting away from the fact that flying isn't faster. … It is sort of counter-intuitive in a way" (Keefer & Ruffus, 2004, p. 5).

bulb and somebody could say 300 and it is… so yes there are those kind of right and wrong." (correct vs incorrect)	
Level 2 Teachers' approach to KTCA is oriented towards knowledge that is list or set of sortable mental content. Teachers' understanding of knowledge consists of knowledge as a set of listable or sortable items. Teacher utterances coded at this level may express the importance of a "need to know" some content matter to create a solid base for classroom instruction. The focus at this level is on being able to name, organize, sequence, list, describe and summarize knowledge. Key Terms/ideas may include: Qualify, Name, Describe, list, itemizable content, address students need to know a listble set of information, sequencing, summarizing, organizing (e.g., 1)" …the bottom line is you need to know work and distance, you need to know mechanical advantage you need to know some specific little things in there" (listable need to know) (e.g., 2) "Your job is to prepare a brief summary of today's reading. The other members of your group will be counting on you to give a quick (one or two minute) statement that conveys the key points or main events of the reading assignment. If there are several main ideas or events to remember, make a list of them." (summarizing, sequencing, list)	Level 2 Teacher's approach to KTCA infers that knowledge is list or set of sortable items" (Keefer & Ruffus, 2004, p. 5). "What are some of the marine organisms in the ocean, at what different levels, what about pollution of the ocean, what are some of the worst kind of pollution" (Keefer & Ruffus, 2004, p. 5).
Approach II	
Level 3 Teachers' approach to knowledge is focused on KTCA that can be represented, interpreted and communicated to others. Teachers' understanding of knowledge consists of knowledge as something that can be communicated. Teachers utterances coded at this level discuss the importance of being able to speak, read and write effectively. The focus at this level is a view knowledge as a tool of communication and teachers may feel students understand a topic if they can discuss it in a group or	Level 3 "Teachers' approach to KTCA and stresses understanding that knowledge can be represented, interpreted and communicated" (Keefer & Ruffus, 2004, p. 5). "Mathematics is a tool to communicate quantitative information. ... The study of mathematics gives you the words and the tools that you can

present to the whole class. Key Terms/ideas may include: Language as a tool, Communicate, Dialogue, share (e.g., 1) "The - no matter what career a child decides to go into they need to know how to read, write, think and speak appropriately, no matter what" (communicate) (e.g., 2) "Students will acquire the knowledge and skills to communicate effectively within and beyond the classroom… review and revise communications to improve accuracy and clarity" (communicate)	communicate what you see happening in a situation. The patterns that you see" (Keefer & Ruffus, 2004, p. 5).
Level 4 Teachers' approach to KTCA focuses on the significance of understanding knowledge from different perspectives, which can help the students to a deeper understanding of the problem Teachers' understanding of knowledge consists of knowledge as viewable from different perspectives. Teacher utterances coded at this level focus on the importance of students discussing and debating a topic in order to hear other people's perspective, as well as employ the use of modeling, graphic organizers, or graphs. Teachers may also discuss the importance of addressing the same issues from different perspectives within a discipline. The focus at this level is on hearing other people's perspective. Key Terms/ideas may include: Compare/contrast, think from another perspective, different perspectives, modeling (to show different perspective), graphic organizers(show knowledge in a different way), debate(for the purpose of hearing other people's perspectives) (e.g., 1) "I want the other students to hear the debate so they can hear the different points of view." (debate for different perspective) (e.g., 2) "I do a lot of case study kinds of things where we try to model processes and we do a lot of modeling. I use a lot of Graphic organizers (modeling and graphic organizers show knowledge." from different perspectives) (e.g., 3) "Explore persuasive essay topics and develop them	Level 4 "Teachers' approach to KTCA focuses on the significance of understanding knowledge from different perspectives, which can help the students to a deeper understanding of the problem" (Keefer & Ruffus, 2004, p. 5). "And that way, when pod 3 hears pod 2 hearing where they are where and they need to go, they may not have thought to go there. Or then they're saying why are they going there? What are they going to gain from having gone there? So it brings up such a higher level thinking processes in the group that didn't think to go there" (Keefer & Ruffus, 2004, p. 5).

with a graphic organizer for the essay through class brainstorming, note taking, or other prewriting methods." (graphic organizer/ communicate)	
Approach III	
Level 5 Teachers' approach to knowledge consists of KTCA as personal artifacts. Teachers' understanding of knowledge consists of knowledge as a personal construction of theories and ideas. Teacher utterances coded at this level focus on teachers/student responsibility for generating their own ideas and creating long term goals for learning. The focus is on a person constructing their own understanding of a situation, building personal theories, or feeling ownership. Key Terms/ideas may include: Make it my own, Making sense of something for oneself, Ownership, Construct, student reflection on personal theories, epistemic agency (e.g., 1) "The need to be able to start and finish labs, do the whole thing, so that they have everything form a sense of ownership to what happens, to them discovering things along the way that I might not have thought of b/c its a canned lab and I've done it so many times." (student ownership over project) (e.g., 2) "Even if it hasn't fully developed in their mind on the activity we're doing at least they're thinking about this concept of mate selection and versus being able to blend in." (students making sense of idea for themselves)	Level 5 "Teachers' approach to KTCA conceptualizes knowledge in terms of personal artifacts" (Keefer & Ruffus, 2004, p. 5). "1 think the best way for students to learn math is once they develop a wonder, a "what if What happens if I do this? What happens if I do that? And out of that what if, then they see general patterns and then they can build on those patterns. It's not just a rote memorization of facts. You have to have that as a tool" (Keefer & Ruffus, 2004, p. 6).
Level 6 Teachers' approach to KTCA is to see themselves and their students as users of knowledge. Teachers' understanding of knowledge consists of knowledge as semi- autonomous and consisting of underlying principles of knowledge. Teacher utterances coded at this level may focus on teachers/students seeing connections, patterns and relationships in the principles of knowledge. The focus at this level may be on the importance of thinking, reasoning, and inferring as well as applying the principles of knowledge. Teachers may also articulate the importance students working on a real-life problem. At this level teachers/students are using and discussing current and past ideas in their domain, as well as	Level 6 "Teachers' approach to KTCA is to see themselves as users and improvers of knowledge. Knowledge is conceived as objective, it can be defended, improved, or effectively critiqued" (Keefer & Ruffus, 2004, p. 5). "…Secondly I don't want them to think that it's [the measurement of angles] an isolated activity done only in math class, because we have to apply our understanding of angles in many other areas of our

underlying principles in a domain. Key Terms/Ideas may include: Prove, Tool, Think/ Logic/ Reason/infer, Apply deep principles of knowledge, Pattern/Connections/ Relationship (to be able to see connections/patterns/relationship implies a deep understanding of knowledge that allows one to use it effectively), defend, knowledge as objective, synthesis(using principles to form a conclusion), think/act like people in the field/ address current issues in the field, impact, focus on the problem, use of authoritative sources (e.g., 1) "Explore how each individual has a relationship with his/her government. Analyze the manipulation tactics used in order to persuade others to think/behave in a certain way…What is the relationship between an individual and his/her government?" (relationship) (e.g., 2) "Well what I was trying to get them to think about was that there is this dynamic interplay between being eaten in your environment, so being camouflaged and being able to blend in and being able to attract a mate successfully. So this borderline this tug-of-war that goes on in sexually dimorphic species, species that look different between the sexes, so is it better for me to be attractive to my mate or live. So that's what the simulation software tried to do because it puts them in different situations. The trials that they set up and ran, they were they could add different varies of guppy male guppies and then they could add different predators and then run it over time to see what would happen, and what they saw was based on the presence or absence of predators, the guppies changed over time too, and so if there was a lot of predators that preyed on certain colors, then those colors would the opposite colors would sort of morph over many generations. The kids all ran them for 10 generations. So it was kind of a neat simulation because it built on everything I just talked about. The very next class period we ran we went through all of their data and processed it some more, and then kind of like landed the plane if you will or made the punch line." (deep understanding) (e.g., 3) "There are just some specific details they just need to have and the overarching question, which might be how simple machines are useful to us?" (application = use)	life. So I chose this because…it is an expansion of where they can decontextualize and recreate something new from the knowledge that they have, which is important for them" (Keefer & Ruffus, 2004, p. 6). J

(e.g., 4) "In my opinion if I had to have one enduring understanding about science it would be that everything is connected…You're going to teach the human body with biology with physics with the chemistry how your muscles work how your digestive system processes all this how your blood the chemistry moves it around whatever. …If we did a unit lets say we're doing Astronomy right now and something comes up lets say about gravity and one of the kids goes didn't we do something with gravity when we were working with simple machines? Or didn't astronomy affect something when blah blah blah whatever it might be so that they would make the connection between the units." (connections)	
Level 7 Teachers' approach to KTCA is to see them and their students as improvers of knowledge. Teachers' approach to knowledge consists of knowledge as semi autonomous and improvable. Teacher utterances coded at this level may discuss the need to question, wonder or play around with an idea, which implies the possibility for improvement. The focus at this level is on improvement so teachers may stress the importance of opening up student work/publishing ideas in the broader community. A teacher may emphasize the importance of debating ideas in order to help find gaps in their own theory/project, which allows for the possibility of improvement. Teachers may also discuss the importance of transferring knowledge and being able to make predictions or hypotheses about a particular situation. Students may work on the creation and improvement of conceptual artifacts Key Terms/ideas may include: Play around with/Curiosity/wonder (can recognize incompleteness of an idea implying possibility for improvement), debate (with the intension that the debate will cause students to rethink and improve ideas/projects), broaden/ expand on previous knowledge/ transfer (to take principles of knowledge apply it to a different situation implies improvement), improvement, deep understanding, non-obvious causal understanding, what if / questioning (recognizes incompleteness and the potential for change), make predictions, control over environment, open discussion to	

the broader knowledge community(assumption the discussion within the broader community will include critique which allows for improvement), publish ideas in the broader community (assumption is once the idea hits the broader community people will critique and improve idea), reflection (reflecting allows opportunity to improve idea/artifact, act like people in the field (e.g., 1) "Um, and it's the best piece we've ever written because what I've done is, I give them this little stamp and if they want me to look at it, they stamp it. So every time they get a draft done, they are like, oh, I want him to look at it so they stamp…And I'm doing a lot of work, but I'm finding that the pieces that I'm looking at are stronger anyway. Huge, no huge, from each draft, each draft is a huge difference. So, it takes me a long time, but that's the learning part for them. Because, then they have to go and say, what's the problem with this and then they peer edit with other people and that's what happening." (drafting = improvement) (e.g., 2) "The whole slang… making up their own word and using it. When we started it, I had to make up their own slang word. And um—Well, because it was a test to see how language forms and how it's used and what we wanted to do was sort of an experiment to see, every kid had to make up their own slang term and start using it. And we wanted to see which ones caught on in school and which ones didn't." (improvement of language/ creating word) (e.g., 3) "And they are drafting and conferencing with me and other people and then publishing the finished piece and that last piece when they are ready to go we have an in class magazine and an in school magazine and I keep track of all the writing contest. so again they are identifying a real audience and getting some feedback which is what actual writers do… the people produce manuscripts or whatever sort of communication and feedback on it. so I'm asking to keep track of it to document it.Well the wed club of st louis offers cash prizes for writers in 10 11 and 12th grade in 2 categories 100 dollars first prize or 150 there's' like first second and third with a cash prize and they go in a book." (acting like people in the field/ conferencing to get feedback to improve piece/putting work into public discourse)	

(e.g., 4) "I think when you get into the sort of um essential kind of questions there aren't right or wrong when you get into the big ideas that people will debate forever and science constantly changes. So truly what we thought, Pluto is a 9th planet. Well yes it was for years and years and years. 19 what it was discovered it 1943 or whatever. Well now it isn't a planet given basis in science is always very willing to change it theories or change what've they've said based on new information and I think that's what's cool about science that not a lot of other specialties or not a lot of other subjects do as well as science does they are always self correcting that's kind of the nature of the beast. Well we just did our astronomy unit so that's going to be one day we kind of do a what if day" (change denotes possibility for improvement)	
Level 8 Teachers' approach to KTCA is oriented towards an understanding that knowledge is autonomous and consists of deep principles that can be applied to problems. Teachers understanding of knowledge consists of knowledge as autonomous and the user understands that knowledge has a life of its own. Teacher utterances coded at this level may focus on knowledge as being interesting in and of itself and may express a belief that knowledge has a life of its own. The focus at this level in on understanding that knowledge is autonomous. Key Terms/ideas may include: Interesting in and of itself, knowledge has a life of its own (e.g., 1) "…but we we've address the nature of science itself numerous time throughout the year. so I try to integrate that so the kids when get out of my class they get a sense for how science actually works." (nature of discipline)	Level 7 "Teachers' approach to KTCA is oriented towards an understanding that knowledge consists of deep principles that are conceptual artifacts and can be applied to problems" (Keefer & Ruffus, 2004, p. 5). "well the mathematics big idea is that [pause] … – you can do a lot with the same amount of area based on the discussions that you make. Um, you have many many choices given a finite amount of space. [pause] You have to then decide how to allocate that space … In social studies they would have said 'You only have a finite amount of space and you must meet societal needs. How will you do that?' In science they would have said 'You only have a set amount of area and you must sustain life, how are you going to do that?'" (Keefer & Ruffus, 2004, p. 6).

Upon further investigating the utterances coded in level 6, the two categories "using knowledge" and "improving knowledge", appeared conceptually different and included noticeably different types of utterances. Because of this, Level 6 has been divided into two levels – Level 6 and a new level 7. Level 6 now reads, "Teachers' approach to KTCA is to see themselves and their students as users of knowledge". Level 7 now reads, "Teachers' approach to KTCA is to see themselves and their students as improvers of knowledge". Before this change, the following four quotes were all coded at the same level, Level 6 (users and improvers of knowledge):

> 1.) [they] use appropriate technology and other resources to locate, select, and organize information to determine relative age of mineral, rock, and soil samples or associated events that might have occurred.
>
> 2.) … [students will] analyze…information and relationships in various fiction and nonfiction works…by analyzing the relationship between literature and a historic period and culture
>
> 3.) The whole slang… making up their own word and using it … And um—Well, because it was a test to see how language forms and how it's used and what we wanted to do was sort of an experiment to see, every kid had to make up their own slang term and start using it. And we wanted to see which ones caught on in school and which ones didn't. And if we could figure out why some did and why some didn't,
>
> 4.) How might we critique this so they get … feedback that helps them make a better project?

In the first two examples, students were required to use knowledge in some way, either an application or seeing connections to help understand a topic better. The second two examples

focus on improving knowledge in some way, by attempting to add a new word to the English language or offering feedback to help peers create a better project. These two ideas, using and improving, appeared to be fundamentally different, with improving knowledge being a more complex idea than using knowledge.

Approach III exemplars. To further clarify the meaning of each of the four levels (Level 5, Level 6, Level 7 and Level 8), exemplars have been added to the ATKS. Each exemplar is followed by a detailed explanation describing why the utterance was coded at that level.

Level 5. Utterances coded at Level 5 of Approach III view knowledge, teaching, curriculum and assessment as personal artifacts. The utterances coded at Level 5 showed teachers discussing the importance of students constructing their own understanding, generating their own ideas about a topic and creating their own goals for learning. This allows students to feel ownership over their learning process. They may also begin to make sense of knowledge and theories for themselves. A student's creation of their own theories, based on class discussions and experiments, is also demonstrated at this level.

Student ownership over the learning process and student creation of personal theories were Level 5 themes that all four teachers recognized and articulated. When Betty (middle school Science teacher) discussed student-run labs, she stated that she believed students, "… need to be able to start and finish labs, do the whole thing, so that they have everything from a sense of ownership to what happens, to them discovering things along the way that I might not have thought of". In the lab sinkers and floaters, detailed in Chapter 4, Betty's students were presented with a scenario and were expected to formulate hypotheses and experiments to test their ideas. The students were in charge of deciding what they felt was the most important factor in the situation, and they were challenged to create their own experiment to test their theories.

This created the possibility of student ownership over the learning process as well as a scenario in which they were expected to create their own theories.

Mel (Communication Arts) also discussed the importance of students developing their own theories. At the beginning of each unit he presented students with an Essential Question and asked the students to, "complete a journal entry, in which they write what they think the [essential] questions and [enduring] understandings mean". By having students write their own ideas or theories about Enduring Understandings and Essential questions throughout the semester, Mel helped to reinforce the idea that students must have ownership over their own learning. He also emphasized the idea that students could create their own personal theories about the course content, which helped to reinforce the idea of knowledge as a personal artifact.

Level 6. Level 6 looked at teachers and students as users of semi-autonomous knowledge. Teachers discussed with the researcher the importance of seeing connections, patterns, and relationships while their students were working on real-life problems. Teachers could also articulate an expectation that their students should be able to reason, and make inferences about topics being discussed in class. All of the teachers in this study stated they know a student understands a fundamental principle, and its usefulness, when he or she made connections across units or disciplines**.** When teachers found their students understanding content as context-free, knowledge became transferable and applicable across lessons or domains and therefore more usable. The more students see the same or similar principles in different contexts the more usable the knowledge becomes.

Betty's discussion of the interconnectedness of teaching Science (mentioned in Chapter 4), exemplified the importance of connections in her response to the interviewer question "What do you think are the Enduring Understandings of Science?" She stated:

> In my opinion if I had to have one enduring understanding about Science it would be that everything is connected. You can't learn Chemistry without Biology or Physics or Environment Science or Earth Sciences. It's all connected. And we tend to teach it in these little separate units and blocks … You're going to teach the human body with Biology, with Physics, with the Chemistry, how your muscles work, how your digestive system processes all this, how your blood…the chemistry moves it around whatever … If we did a unit … lets say we're doing Astronomy right now and something comes up, lets say about gravity and one of the kids goes 'didn't we do something with gravity when we were working with simple machines?' Or 'didn't astronomy affect something' when… whatever it might be…so that they would make the connection between the units.

The idea of connections was demonstrated again with Betty's Essential Question, "How are earthquakes related to convection currents?" When she was asked what she felt was most important for her students to understand this year, she responded by saying

> Probably convection currents, [that they] drive a lot of the earth processes. Convection currents not only would move tectonic plates causing earthquakes and volcanoes, but also… because convection currents cause weather as well …

In both the quote from her unit plan and her answer to the aforementioned question, Betty constantly impressed upon her students connections between ideas. It was important for students to see that convection currents cause shifts in tectonic plates, which causes earthquakes and volcanic eruptions, and that convection current principles weren't only applicable to changes in weather. She believed her students had a deep understanding of convection currents when they could recognize the impact of convection currents across seemingly unrelated topics. It was necessary for her students to be able to see the complex relationship and impact of convection

currents on plate movement, weather, and natural disasters. Betty felt her students had to understand the underlying principles of convection currents before her students could see the principles of convection currents as "context-free". By seeing the underlying principles context-free, she felt this would facilitate the students transferring and using this knowledge seemingly non-obvious situations. She hoped her focus on connections would prompt the students to ask, "In what other situation would this principle (knowledge) be useful?

Mel also demonstrated this notion of the importance of connections and patterns in his unit, "The Individual and His Government". His middle school students learned about revolution, propaganda and literary techniques that are powerful in persuading an audience, through reading *Animal Farm*, *Zlata's Diary*, and *Red Scarf Girl***.** The Enduring Understanding and Essential Question the students and teacher addressed was, "People commonly use manipulation tactics in order to persuade others to act a certain way" and "How do people twist words/ideas around in order to persuade others to act in a certain way?" In this unit students were analyzing literary techniques used in fiction to help them understand the techniques used in propaganda and the way in which propaganda impacts historical events. Students also used the ideas to better understand the relationship between an individual and his or her government.

In order to do this effectively, students had to connect three things: how fiction relates to history, how persuasive literary techniques used in fiction are also used in propaganda, and how literary techniques manipulate people to think and behave in a specific manner. In this unit, Mel presented his students with multi-layered and complex concepts in Level 6 - connections and relationships, and expected them to apply these ideas to help understand the relationship between an individual and the government.

Betty explained the theme of application using her simple machines unit. While she acknowledged the importance of being able to recall and memorize many of the important ideas and formulas associated with simple machines, this declarative knowledge was not the focus. As she states, the focus of the unit was, "how [are] simple machines useful to us?" This question demonstrated that the ideas presented in the simple machines unit were applicable to students' lives. By focusing on real life use and applicability of simple machines, she was allowing the concepts to be usable and her students to become users of this knowledge.

Level 7. Students and teachers saw knowledge at this level as something that still belonged to them but could be effectively critiqued. Teacher discussions coded at this level focused on the need for students to question, to wonder, or to play around with an idea.

Teachers also stressed three concepts: the importance of opening up student work/publishing ideas in the broader community; the importance of debating ideas in order to help find gaps in their own theory/project; and the importance of transferring knowledge and being able to make predictions or hypotheses about a particular situation. All of these ideas could lead to change or improvement. While this view of knowledge may not guarantee improvement of knowledge, it created this possibility for students in these classrooms.

Improvement was also demonstrated on a more individual level by enforcing the idea that student work (projects, papers, etc.) was always a "work in progress". It was at this stage that students changed from simply using knowledge to improving it, by making it more effective for a given situation. To improve knowledge appeared to be a difficult task for middle and high school students, however improvement did not mean that students were creating new knowledge rather, they were able to render knowledge more useful for a particular situation. It could also be an acknowledgement that understandings of topics were consistently evolving as new discoveries

were made. In this sense, it is possible to conceive that knowledge presented in school is not necessarily absolute truth. As Betty expressed, she tried to instill in her students that "… Science is always very willing to change its theories … what've they've said based on new information … they are always self correcting".

In this example students or teachers were not "improving knowledge" rather, Betty was setting up the idea that disciplines are always "self correcting" and knowledge was always changing. Understanding that knowledge is always changing sets the stage for her students to view knowledge as something that is constantly improving.

Improvements of knowledge through the improvement of a student's own conceptual artifacts were a theme that emerged consistently in the middle and high school English teachers' interviews. Both classes promoted students becoming "real" readers: people who participated in book clubs, actively choosing what they read and discussed; and real writers who work-shopped and revised their work. As Mel clarified, by constantly requiring students to go back to their works and revise it, students were in a sense improving their own ideas

> … it would be content revisions and that would be like them saying, in a paragraph, first I did this and then I did this, then I did this, then I did this. Just listing events, well, then I'll look at it and give them suggestions like 'add details, add explanation'. I want to see it and feel it, not just read it. So the next time I see it that paragraph is twice as long and then they are talking about sensory images, things they remember smelling and feeling as opposed to 'I did this, I did this …' Yes, by now, every single final piece we do and there is about eight [revisions] …

At the high school level this process of becoming real readers and writers became more complex with more student freedom. When reading these works, the students' focus was not on

the "who, what, when, where" of the book, but instead on how the author effectively used various literary techniques employed by a particular genre to create an effect, a mood or a tone. This method allowed the entire class to have group discussions based on a literary technique, even though all students did not read the same material. At his/her own pace, students were also expected to write their own original work (conceptual artifact) in the style of each of the covered genres. As Drew explained, these high school students (much like the middle school students) were consistently, "drafting and conferencing with me and other people … then publishing the finished piece…". After students received feedback from their peers and teachers, they were also expected to publish their work. "They are identifying a real audience and getting some feedback which is what actual writers do … the people produce manuscripts or whatever sort of communication and feedback on it …". This allowed students to open their work up to the larger community of writers to receive feedback and critique on their writings.

Level 8. In the final stage of Approach III, Level 8, teachers and students understand knowledge as something that is autonomous, that has a life of its own. At this level knowledge is also understood to consist of deep principles of a domain. When teachers discuss knowledge, teaching, curriculum, and assessment at this level, they may discuss the importance of knowledge being interesting in and of itself. There were only three instances of teacher utterances at this level. All three were by the same teacher, Carl, whose utterances coded at this level focused on the nature of Science:

> … we, we've address the nature of Science itself numerous time throughout the year … I try to integrate that so the kids when get out of my class they get a sense for how Science actually works. To me I want kids to be able to think how Science works. I do a lot of nature Science teaching during lessons …

In both of these quotes Carl focused on the nature of the discipline. By asking students to understand the "nature" of Science, he was asking them to look at the deep principles of Science, which are completely independent or autonomous from the student's personal beliefs. While the students might not understand Science at this deep level Carl still exposed his students to the "nature" of Science and the autonomy of scientific ideas.

Summary of Results

After investigating the usefulness of the ATKS and relevant changes, it appeared that the ATKS was considered an applicable tool. Since the ideas associated with knowledge work, as expressed in the ATKS, can have a myriad of definitions, one main focus was on developing further explanations of what each level means through expanded definitions, new exemplars, and key terms. Additional definitions were added to further expand and clarify the meaning of each topic.

However, there are further improvements to be made in the ATKS tool. The addition of key terms pulled from this data set was also intended to clarify what type of utterance would be coded at each level. As stated earlier, Approach III was of high interest because it addresses the ideas presented in Knowledge Building/knowledge work. The participants' views were expected to help further articulate an epistemology that is consistent with the Knowledge Age while modifying the categories in the Approach to Knowledge Scheme. This adapted scheme, in Approach III, provided categorization and descriptions of how the tenets (epistemic agency, improvable ideas, idea diversity and conceptual artifacts) of Knowledge Building could be understood from a teacher's perspective.

A new level was also added to the ATKS. The most important conceptual change made in the ATKS was the splitting of Level 6 (users and improvers of knowledge) into two levels:

Level 6 (users) and Level 7 (improvers). It was determined that, users and improvers, were really two different, but equally important, aspects of Knowledge Building.

Chapter 6 Discussion and Conclusions

This collective case study (Berg, 2004; Stake, 1994) was designed to examine the following two research questions:

1.) What are teachers' epistemological beliefs and pedagogical practices in a PBL setting?

2.) Is the Approach to Knowledge Scheme an applicable tool to use with teachers and how can it be further modified to better reflect the ideas of the Knowledge Age?

There is little mention of the Knowledge Age or knowledge workers in educational literature and practice, even though there is a plethora of articles and studies in business and economic literature covering these ideas. If, as some researchers (e.g., Griffith, 2005; King, 2006; Reich, 2005) suggest, schools are the cornerstone of the new Knowledge Age and are responsible for educating knowledge workers, the question becomes: why is there so little mention of it in education, much less the implementation, of the principles of knowledge work? With the exception of the group Institute for Knowledge Innovation and Technology (Bereiter, 2002a; Scardamalia, 2002; Scardamalia & Bereiter, 2003; Tan, Hung, & Scardamalia, 2006) and their associates, there is little to no discussion of the role education must play in preparing students to be a vital part of this new knowledge age in education. Education is the foundation of a successful economy for the Knowledge Age and the production of its knowledge workers. This necessitates a more in depth understanding of what epistemological beliefs and corresponding pedagogical practices would foster students who can work successfully in the Knowledge Age. The researchers associated with the Institute for Knowledge Innovation and Technology are actively involved in bridging this gap, but their work tends to focus on student

beliefs and the use of the computer program, Knowledge Forum, which is intended to help students participate in knowledge building. To date there are only two studies (Keefer & Ruffus, 2004; Ruffus Doerr et. al, 2007) looking at teachers' understanding of knowledge or their level/depth of understanding relating to knowledge work. Considering the research demonstrating the impact of teacher's epistemology on students (Chan & Elliot, 2004; Johnson, Woodside, & Day, 2001; Kang & Wallace, 2004), this study focused on teachers' epistemological beliefs and pedagogical practices as well as the utility of the ATKS. It was the intention of this investigation to begin to explore teachers' roles in a new knowledge based world.

Discussion

The findings of this study suggest important implications regarding educating students for the Knowledge Age. While there is research on Knowledge Building in other disciplines, there is little research on this topic in education. This study suggests that these four teachers practiced some of the principles of Knowledge Building in a Problem Based Learning (PBL) setting and also demonstrated some of the ideas presented in the business literature. It is interesting to note that the curriculum framework used in their school, Understanding by Design (UBD), focuses on teaching deep understandings of the topics, and "teaching for understanding". This curriculum framework may have aided teachers working at Approach III (Knowledge Building) and may have facilitated some insight into how education can prepare knowledge workers.

The Sciences participants, Betty and Carl, both discussed the importance of students having a deep understanding of Science in order to see complex Patterns and Connections. The two teachers both believed that when students focus on a problem and seek a deep understanding

of that problem (like the impact of DDT, convection currents or even the complexity involved in mate selection), they end up fully comprehending the underlying principles and quickly recognize the non-obvious causal relationships (Bereiter & Scardamalia, 1998) found in Science. These examples suggest how some components of Knowledge Building Discourse (focus on a problem, depth of understanding; Scardamalia & Bereiter, 2003) can be integrated into a Science PBL classroom.

Betty's use of the JIGSAW method in her Astronomy unit indicated a classroom solution to a problem business researchers address: Knowledge Work is too complex and big and needs to be done in groups in order to be effective (Lewis, 2004; Shani, 2000). This research also suggests that such a group must consist of members with various specializations, much like the JIGSAW method is intended to work. Students are given an area of expertise and are put together in groups for knowledge sharing with members of other expert groups. Betty's goal was for knowledge sharing to take place in large and diverse groups (Swang, 2006). Her implementation of the JIGSAW method suggests she could be facilitating her students to become Knowledge Communicators (Machlup, 1998; Rubin and Huber, 1998).

Both teachers became noticeably more animated, and articulated ideas relevant to the Knowledge Age, when discussing how Science is constantly changing and constantly improving itself. Betty demonstrated how improvable knowledge could be integrated into a PBL classroom with her final assessment of the "Earth Rocks" unit, in which students were required to "rewrite" a chapter in their textbook and submit it to the publisher for consideration. The final assessment allowed her students to become knowledge builders by improving something (a book chapter) and by getting it out into the community (submitting it to the publisher; Scardamalia, 2002). Carl also stressed improvement in Science by constantly impressing upon his students that

science is on the "cutting edge" and that there, "is so much we don't know". Since most of his students think of Science as a group of indisputable facts, this is quite a revelation. To say that there is so much out there yet to be discovered suggests that we (Scientists) can improve our understanding of the world. This demonstrates to the students that knowledge, in Science, is improvable and that nothing currently in Science is an absolute truth.

When Betty and Carl focused on the importance of asking questions, both teachers allowed their students to be in control of solving the problem by allowing them to choose which variables and settings impacted the experiment. Students made these choices after discussing their thoughts within a group (idea diversity), which also allowed them to hear and use conflicting ideas before they decided on a path of learning (epistemic agency; Scardamalia, 2002). By tapping into student curiosity and demonstrating how Scientists ask questions, Carl and Betty hoped their students would see that Science is about asking questions to find out about the world.

They also hoped these questions would lead students to understand that Science is current, constantly changing, and relevant. The importance of this idea and its relevance to the Knowledge Age was best summed up in one of Carl's questions, "How does understanding the living world help us solve our problems?" To help students wrestle with the current issues of the day through the use of debates, he allowed students to see others' perspectives (idea diversity), and stressed the importance of conflicting ideas to help with knowledge advancement (Epistemic Agency; Scardamalia, 2002). While knowledge advancement seemed like a tall order for a high school debate, one must remember that knowledge building can be as "simple" and straightforward as "Mendel worked on Karen's problem" (Scardamalia, Bereiter, & Lamon, 1994, p. 210).

Both English/Communication Arts participants also demonstrated useful ideas of Knowledge Building and effective group structure for knowledge sharing and knowledge improving. These topics revealed various aspect of Knowledge Building throughout the data: epistemic agency, idea diversity, improvable ideas and components of knowledge building discourse (opening up discourse to the larger community and deep understanding).

Mel (Middle School Communication Arts) demonstrated improvablity of ideas and opening the discussion to the broader knowledge community (Scardamalia, 2002) by making his students create slang words. The students had to "test" the slang world by attempting to use it and see what "caught on". When the students created their own slang word, Mel demonstrated the improvability and changeable nature of language as well as pushing his students to put their ideas (new word) out into the larger community (their school) for critique. Mel stressed that it was important that his students understood that language was improving, developing, and evolving as opposed to something that was stale and belonged to, as he stated, "a middle-aged white guy." Students could now see themselves as having the power to improve and change language with this unit. They needed to have a deep understanding of language, as well as a deep understanding of slang, for them to create an effective slang word, meaning one that would catch on and become commonly used within their community.

Both Mel and Drew extensively discussed the implementation of literature circles and book clubs as a way of creating real readers. Traditionally, the entire class reads a single book that has been determined by the teacher. The teacher further decides the dates that each chapter is to be read and what topics in the book the class will discuss. The teacher also leads and drives the discussion, based on what he/she wants students to learn. Mel and Drew's implementation of literature circles/book clubs allowed and even demanded, that students choose what books to

read and at what pace to read them. The students, not the teachers, identified topics in the books for detailed discussion and the aspects of the books they found to be most relevant. In the literature circles students discussed their own interpretation of the book, what they found most compelling, and what they found most useful. They were in charge of the focus of their discussion, reading pace, and group interaction. By allowing students to propose their own ideas, propose their own learning goals and evaluate their success against goals they established, the teachers were demonstrating epistemic agency (Scardamalia, 2002) in their classrooms. The literature circles also promoted idea diversity (Scardamalia, 2002). Not all the students agreed on the aforementioned issues, or even the importance of a particular passage, so the discussion that took place in literature circles allowed students to see other perspectives, even conflicting ones. That debate can enhance students' understandings or even increase the value of what the students got out of the book. Further, the purpose of the literature circles/book clubs was to share knowledge and perspectives about the books. The larger numbers and diversity of students in these groups was a structure that facilitated knowledge sharing (Sawng et. al. 2006).

The conferencing/workshopping and publication of student work suggested how to integrate the improvability of idea in an English classroom. Seeing writing as a cyclical and improvable idea is a shift away from the more traditional way of writing in English, or knowledge telling (Scardamalia & Bereiter, 1986), where student essays consist of a list of what they know about the topic. As Drew stated, "you know in the old days write an essay on to Kill a Mockingbird and the teacher reads it and says "B" and the teacher's the only person who's ever read it so there's not there tends not to be on the part of the student that there is real communication happening". With the approach of conferencing, there is real communication between student and teacher. Students have to accept that writing drafts are not final but that

they have to spend time getting feedback to improve their work. In other words they have to see their writing as authentic, recursive, and complex, or knowledge transforming (Scardamalia & Bereiter, 1986). By demanding that students publish their work, Mel and Drew are decentralizing the process of Knowledge Building and opening up students' ideas to the broader knowledge communities, (Bereiter, 2002a) an important component of knowledge building discourse (Scardamalia, 2002). As both participants stated throughout the interviews, when students submit their work, it was to get a broader perspective of their work and to get critiques from the outside community on how to improve each piece, much like their professional counterparts do. Workshopping/conferencing meant to facilitate knowledge improvement was done in small cohesive groups (Swang, 2006) and may in fact be precisely the kind of training students need to work in Knowledge Building groups.

Interestingly, the participants in this study demonstrated many of the core ideas of Knowledge Building (Scardamalia, 2002), despite the fact that they taught significantly divergent subjects and age groups. Considering that the participants taught in the Sciences and Humanities, two very different disciplines, there was an anticipation that coding levels between the disciplines would be different and that one discipline might code consistently higher. This was not the case with these participants. All four teachers participated in Knowledge Building in a discipline-appropriate way. For example, knowledge improvability was demonstrated in different ways in English classes (workshopping, cyclical process of writing) than in Science classes (Science is always changing, importance of improving theory). It is unclear if this commonality in coding results is because of the participants' understandings of their discipline (because all four participants work at the same school with the same teaching philosophy), or

because there is no difference between disciplines with respect to the amount of Knowledge Building being done.

It appears that the four participants at this particular school are promoting ideas of Knowledge Building. This study suggests that researchers may continue to identify ways in which teachers can adjust concepts and methodologies already understood in a problem based learning (PBL) environment. An increasingly popular curricular framework (UBD) can also be used to aid in curriculum design.

These findings also suggest these particular four educators may have epistemological beliefs and pedagogical practices consistent with the ideas of the Knowledge Age and may be better able to prepare knowledge workers. In this particular educational environment, a fundamental shift in education as suggested by the business literature may not be necessary but, adjustments to include other principles of Knowledge Building would be helpful.

The findings relating to the ATKS also have important implications for education. Since Knowledge Building takes place in Approach III, this scheme can facilitate an understanding of how much "Knowledge Building" is going on in the classroom by categorizing teacher utterances by their approach to knowledge. The ATKS may also be useful by providing a tool for researchers to use in discussions with teachers about methods teachers may adopt to improve the education process in their individual classrooms.

With the expanded definitions and exemplars, the ATKS could also be utilized to help teachers deepen their understanding of Knowledge Building through the definitions and examples in a classroom setting. This deepened understanding may help teachers' implementations of Knowledge Building in the classroom.

Limitations

There were several limitations to this study. First, the research design of a collective case study consisting of four instrumental case studies was chosen in part because of the limited research in this area. The intention of the collective (instrumental) case study was to offer insight into a topic (Berg, 2004) as well as clarify a theoretical idea to help further understanding (Stake, 1994). Further, theoretical sampling of expert teachers was chosen because it was believed they could provide insight into the developing theory. While this type of sampling suited the research, it does not address the population of novice teachers, who may have significantly different beliefs. It must be noted that, because of the limited data set and limited number of participants, the results of this study cannot be immediately generalized to the general population of educators. This result speaks only to these four specific participants, in their specific environment, and leaves open the possibility that similar approaches might currently be used by at least some teachers.

Another limitation involves the data collection and coding effort regarding classroom observation data and the post interview data. In order for case studies to have increased validity, multiple data points were collected for this research project. The data points collected to allow triangulation of the data were: pre-observation interview, classroom observation, unit plans, and post observation interview. The purpose of the observation was to see if what the teachers talked about in the pre-interviews correlated to how they behaved in the classroom. The original intent was to code these teacher utterances. However, after the observations it became clear that this was not going to be an effective way to collect the data. In each of the classes, students were constantly in and out of the class, obtaining different resources, and working on various projects. Because the classes were student centered, the majority of the teacher comments during class were intended to facilitate student thinking or get students back on track for a project. Some

examples of these teacher utterances include: “What stage are you in”; “Well, that’s the question you need to answer”; “Do the kinds of predators matter?” Students, who were not the focus of this study, made most of the content-related comments. The classroom observations were useful in that they provided the researcher with a holistic understanding of the teacher, they did not provide any evidence to refute the interviews and unit plans, and they aided the researcher in creating the post observation interview. However, these teacher utterances were not codable according to the ATKS as was originally intended at the outset of this research.

The final limitation related to the post observation interview information. It was expected that the post observation interview, with questions focused on the classroom observation would provide a richer set of data, as the teacher would have a specific class to relate the questions. When teachers were asked questions such as, “What do you think was the most important concept/principles for students to learn during this lesson?” “What worked?” “What didn’t work?”, the responses tended to focus more on inhibiting characteristics of students and the administration instead of content related responses. Their responses often contained non-content issues, such as a student who was struggling because of personal issues, limitations imposed on the teachers by administration, or state imposed standards.

Recommendations for Future Research

Although this study initiates the conversation about educating students for the Knowledge Age, further research is needed to increase our understanding. First, additional research with more participants from both this district and other districts that promote the PBL environment and a UBD framework would be useful. While this sample of four teachers provided a plethora of data and many exciting insights, further investigation involving more participants with varied levels of experience, in varied geographical areas and varied student

populations could provide more insight into the applicability of Knowledge Building in a PBL classroom not revealed by these four participants. It would also be beneficial to study participants in other areas of education (History, Mathematics, Visual Arts…) to investigate the applicability of Knowledge Building in these different disciplines.

Second, additional research on the ATKS would be helpful in categorizing and explicating teachers' epistemological beliefs and pedagogical practices as it relates to the Knowledge Age. While the use of this tool and coding procedures have been established in published research (Keefer & Ruffus, 2004; Ruffus et. al, 2007), further training with other researchers to code the ATKS would be beneficial to check for inter-rater reliability, which could lead to further clarifications in coding procedures, definitions, and key terms. Making the ATKS even more explicit in terms of what gets coded, and establishing a more rigorous coding protocol, could help us understand the validity and usefulness of this tool.

Third, further investigation into the relevance of Knowledge Building as a theory to guide the education of students for the changing needs of the Knowledge Age is essential. Not all components of Knowledge Building were prevalent or examined in this particular data set. The principles needing further investigation include: Concurrent, embedded, and transformative assessment; Community knowledge collective responsibility; real ideas and authentic problems; democratizing knowledge; symmetric knowledge advancement; rise above; and pervasive Knowledge Building.

Fourth, it would be beneficial to investigate the beliefs and practices of novice teachers. This research could begin to address the questions, "do we need to train novice and even pre-service teachers differently so they can prepare students adequately for the Knowledge Age?" as

well as, “How do teachers evolve from novice to expert teachers and does that evolution help them prepare students to become knowledge workers?”

Finally, a study observing the level of knowledge work that both students and teachers are actually doing simultaneously would be of interest and would help enrich the understanding that each must play in Knowledge Building educational settings.

Conclusions

These findings suggest that some of the ideas cited in business literature discussions on how to succeed in the new Knowledge Age are applicable to education and in fact are already being implemented by at least the four teachers in this particular school. These findings suggest that it may be easier to close the gap between the business world and education’s view of educating for the Knowledge Age than might have been previously thought.

This study also suggests that the ATKS is a tool that may help categorize a teacher’s approach to knowledge. In particular, Approach III, which demonstrates many of the important concepts for the Knowledge Age, may help researchers understand and categorize the principles of Knowledge Building demonstrated in the classroom.

This study represents a first step in investigating teachers beliefs and practices in a PBL environment and the use of the ATKS to understand teachers’ approaches to knowledge. The ability to legitimately codify teacher practices and their inevitable impact on student learning will be crucial as schools face increasing demand that the students in the United States keep pace, and hopefully surpass, the needs of the Knowledge Age.

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Appendix A

Semi-Structured Content Knowledge Pre-observation Interview

Content Knowledge
I What is important about X?
P1 What is X to you?
P2 If you wanted your students to develop a love of X what would you want your students to know?

I What do you think is the best way to approach the teaching of x? Why?
P1 How do you structure the teaching of x in you classroom?
P2 What is the best way for students to approach learning about x?
P3 Do you think this approach/structure facilitates students ability to learn about x?

I What do you think might be the deep principles/enduring understandings/concepts of x?
P1 How do you know you have learned or grasped an understanding of x?
P2 What are the indications that someone is knowledgeable about x?

I what is the best way to organize x so that it can be best understood by students?
P1 Do you think it changes from subject to subject?

I What do you think is most important for students to learn about x?
P1 When students leave your class at the end of the year, what do you think is most important for them to understand or know?

I Do you think there are clear right or wrong answers in x?
P1 Can your students complete assignments in different ways?
P2 Do you give assignments that students can answer in different ways?

I Do your students have an opportunity to improve or re-do their assignments? Why or Why not?
P1 What type of feedback do you provide on assignments? Can you give an example?

I Do your students believe the ideas presented in your class are debatable? (If yes) How do you facilitate this?
P1 Do your students have the opportunity to critique the work of other students? If so what are the anticipated benefits of this critique?
P2 I Do you/how do you instill the idea that knowledge is criticizable in your students?

I What type of application do you expect your students to use with the knowledge taught in class?

I How do you use to assess students understanding of x?

P1 What indications did you see in this lesson that your students did or did not have a understanding of

Appendix B
Semi-Structured Content Knowledge Post-observation Interview

I What worked in this lesson?

I What didn't work?

I What do you think was the most important concept/principles for students to learn during this lesson?

P1 What was the deep understanding/enduring understanding you wanted your students to have after this lesson?

P2 Do you feel your students have grasped a understanding of X?

P3 What indications did you see in this lesson that your students did or did not have an understanding of X?

P4 How will/did you assess a student's understanding of topic x?

I Were there were clear right or wrong answers in this lesson that you wanted your students to understand?

P1 Can your students complete assignments in different ways?
P2 Do you give assignments that students can answer in different ways?

I What would you change or revise about the lesson the next time you teach it? Why?

I How well did this teaching episode fit with your prior expectations?

Appendix C

Carl-Biology Unit

This course will immerse students in rich content that is filled with big ideas and probing questions. The course will be broken into eight units, each focusing on the perspective of a scientist in a particular branch of biology. The 10th grade students in this course will assume a variety of different roles as they explore the main themes in Biology. For example students will study science from the perspective of a biologist ecologist or geneticist. The course offers many opportunities for students to apply the concepts and ideas they are learning to really assessment situations. The course will also employ a rich variety of hands on instructional methods including inquiry based labs and the use of technology and simulations. Finally the course will attempt to deep student awareness of the complexity of life as it functions at many levels.

Enduring understanding for the course:

Observing the natural world from different scientific perspectives can lead to an increased understanding of how humans fit into it.
Scientific inference results from combining prior knowledge with scientific observation.
The natural world is regular and predictable
Life functions as a complex system that exists at many different levels

Essential questions for the course

How can different scientists' influence and perspectives lead us to a greater understanding of the natural world?
How can scientific inference be observed in the natural world?
What kinds of patterns can be observed in a changing world?
How can scientists lead us to understanding how life functions as a system?
How can we explore our world to better understand our relationship to it?
Students in this course will answer the following question while completing each of the eight units of study: How does a (n)_____ come to know the world and human's place in it?

Assessment evidence"

Semester One and Two Essay Questions
Choose two of the following roles from first/second semester's units and answer the following essential question: Biologist, Ecologist, Biochemist, or Cell Biologist
How can different scientists' influences and perspectives lead us to a greater understanding of the natural world?
Answer two of the following essay question while demonstrating what you learned this semester
How can scientists lead us to understanding how life functions as a system?
How can we explore our world to better understand our relationship to it?
How can scientific inference be observed in the natural world?
What kinds of patterns can be observed in a changing world?

Biology Course requirements and student expectations:

Class participation will play a major role in the students' understanding of Biology. Therefore daily attendance is expected and required for all students. Also students need to bring their

student planners to class. Daily and weekly and weekly assignments will aid in the practice of the students' understanding of Biology. Neatness and accuracy will be an essential component of all assignments. Completion of all assignments will be required by the due date in order to receive full credit. See Mr. McWilliams' homework policy for more information
A written evaluation will be used as the tool to measure the students' personal success at understanding biology. Other forms of evaluation will also be used. All students will be expected to take the evaluations. Make-up evolutions can be scheduled before and after school. Extra help with assignments, reading and labs may also be arranged before school after school or during advisory. Students will come to class prepared with pen/pencil, biology textbook and biology textbook and biology folder. Biology journals will be provided for you and will remain in the classroom. All of these items are essential to your success in Biology. Class preparedness also includes reading chapter laboratory assignments prior to entering the classroom. Students need to bring their Biology Folder to each class period.

Biology grading procedure

Quarter grades will be based upon an accumulation of points distributed among the categories listed below.
Grades will be calculated based upon each student's points total divided by the total points possible total

Betty-Earth Rocks! Unit

Brief Summary of Unit

Students will explore the geological history of plate motion and how it has affected the surface of the Earth. From Pangaea to the present, students will gain an understanding of the power of Earth's processes.

Stage 1—Desired Results

Established Goals: 5:2: Earth systems interact with one another as they undergo change by common processes.

Enduring Understandings: U

(EU 1) There are internal processes that cause changes in Earth's crustal plates.
(EU2) Changes in the Earth over time can be inferred through rock and fossil evidence.
(EU 3) Earth's systems have common components.

Essential Questions: Q

(EQ1) How do convection currents create mountains?
(EQ2) How can we determine the past geological history of the Earth?
(EQ3) How do the Earth's systems interact?

Students will know…

K

• Rocks and minerals can be classified
by their chemical and physical properties.
• Surface and subsurface rock and mineral deposits lead to the determination of age, origin, and events in the Earth's history.
• Formation of layers of sedimentary rock and their associated fossils confirm the long history of Earth and its changing life forms.
• The surface of the Earth has changed as a result of dynamic forces originating within the

mantle.

Students will be able to… S

• Conduct research using chemical testing and evaluate the information to classify a variety of rocks and minerals.

• Use appropriate technology and other resources to locate, select, and organize information to determine relative age of mineral, rock, and soil samples or associated events that might have occurred.

• Construct models and geological profiles to demonstrate the age relationship of sedimentary rock layers.

Stage 2—Assessment Evidence

Performance Task: A textbook company wanting to upgrade their Earth science unit has approached the 8th grade. The company would like you to revamp their Earth unit to make it more current. They are willing to have the information in any form: power point, skit, rap, game, etc… The company has provided a rubric so you will know what content must be covered.

G: Your task is to jazz up the Earth science unit.

R: You are on a team of curriculum designers using your knowledge of Earth processes to create an engaging educational unit.

A: Your target audience is the up coming 7th graders.

S: The challenge is to design an engaging unit that is educational.

P: Your product will be the completed unit.

S: You will be judged on your adherence to the rubric.

Other Evidence: OE

Rock/mineral assessment

Labs on: rocks/minerals

Law of Superposition activity

Simulating half-life

Volcano/Earthquake plots

In Class work- http://volcano.und.nodak.edu/vwdocs/vwlessons/lessons/Earths

USGS *Who Dunnit- Law of Superposition*

Reflections on Do Nows

Readings and prompts from Dynamic Earth

EdHelper homework prompts

Stage 3—Learning Plan

Learning Activities—Considered the WHERE elements L

W

• Overview of unit

• Answer EQ's as journal prompts

• Movie on Earth beginnings

H

• Labs using rocks and minerals

• Performance Event

• Movies on Earthquakes/volcanoes

• Interactive computer work on earthquakes and volcanoes

E

• Define: superposition, Pangaea, convection currents, s-waves. p-waves, subduction zone

• Review mineral tests: (chemical and physical)
• Readings and prompts from Prentices Hall *Dynamic Earth*
• Sharing rubric for performance event
• Demonstrations on convection currents, fault types
• Scaffold sheet for performance event

R

• Journal prompts related to the EU's and EQ's
• Homework
• Self correcting pre-test

E

• Study Guides prior to assessments
• Self- reflecting post assessment guides and post performance event

Earth Rocks Timeline
Intro timeline What are we going to be doing?
Rock pre-test Evidence for Pangaea
readings, prompts, video clip, Law of Superposition lab, Indicator fossil lab, Difference between rocks and minerals, Mineral tests Lab, Mystery mineral, Rock characteristics, Grain size-intrusive vs.extrusive, Rock cycle, Movie on Pangaea with prompts, Convection Current introduction demo, Computer work on crustal plate movement, Plotting volcano/earthquakes Performance Event, Intro/start research, Performance Event, research, Performance Event Work with partners on final product, Performance Event, Work with partners on final product, Present

Drew-Reading and Literary Analysis Unit

Link to State Standards: Performance Standards
GOAL 1: Students will acquire the knowledge and skills to gather, analyze and apply information and ideas. *Students will*

5. comprehend and evaluate written, visual and oral presentations and works

6. discover and evaluate patterns and relationships in information, ideas and structures

9. identify, analyze and compare the institutions, traditions and art forms of past and present societies

GOAL 2: Students will acquire the knowledge and skills to communicate effectively within and beyond the classroom. *Students will*

1. plan and make written, oral and visual presentations for a variety of purposes and audiences

2. review and revise communications to improve accuracy and clarity

3. exchange information, questions and ideas while recognizing the perspectives of others

4. present perceptions and ideas regarding works of the arts, humanities and sciences

GOAL 4: Students will acquire the knowledge and skills to make decisions and act as responsible members of society. *Students will*

4. recognize and practice honesty and integrity in academic work and in the workplace

5. develop, monitor and revise plans of action to meet deadlines and accomplish goals

6. identify tasks that require a coordinated effort and work with others to complete those tasks

Knowledge Standards

Students will acquire knowledge of and proficiency in

1. speaking and writing standard English (including grammar, usage, punctuation, spelling, capitalization)

2. reading and evaluating fiction, poetry and drama

4. writing formally (such as reports, narratives, essays) and informally (such as outlines, notes)

6. participating in formal and informal presentations and discussions of issues and ideas

7. identifying and evaluating relationships between language and culture

Brief Summary of Unit

Students begin the semester becoming familiar with the cognitive processes involved in making meaning from text known as "The Seven Habits of Effective Readers." They form cooperative reading groups, or literature circles, and discuss not only the content of the readings but also their own reading processes and observations about the act of reading itself. Students then go on to read one or more independently chosen titles, and then the whole class reads George Orwell's *1984* or a series of shorter, whole-class, texts. While reading, students keep a reading notebook in which they record a few essential plot items, instances of literary devices and the way in which they function, and also things they notice about their own reading processes. At the end of the whole-class study segment, students write a literary analysis essay.

<u>Enduring Understanding</u>

- Reading is fundamental
- The meaning of some texts is discovered not through merely decoding but by reading between the lines, in the interaction between the active reader and the text (Wiggins & McTighe)

- Immersion in reading, the "Flow" experience, is only possible when the reader encounters a text at the appropriate level of challenge to the reader and when the topic is of interest
- Writing about what you read can increase your understanding of what you have read and also what you read next
- There are times for active reading and times for passive reading
- Through literature circles and other structures, reading can be a social act: yes, reading can help your social life!

Essential Questions

- What habits do successful readers have?
- How can I achieve "Flow" as a reader?
- When a reader becomes confused, what should he or she do to increase comprehension?
- How does an author "mean"?
- How do literary devices cause a work achieve its affect?

Key Knowledge and Skills

Students will

- read and evaluate several novels and some shorter works
- identify, analyze and compare the institutions, traditions and art forms of past and present societies
- discover and evaluate patterns and relationships in information, ideas and structures
- participate in formal and informal presentations and discussions of issues and ideas
- write formally a literary analysis essay and other examples of summative and evaluative comments on texts and informally such as notes and lists

Students will be able to

- discover and evaluate patterns and relationships in information, ideas and structures
- exchange information, questions and ideas while recognizing the perspectives of others
- write formally (such as reports, narratives, essays) and informally (such as outlines, notes)
- identify and evaluating relationships between language and culture

Students will continue to study, identify, and analyze how writers use various techniques to contribute to the overall meaning of a text. Techniques may include:

Character, Plot, Sub-plot, Exposition, Development, Climax, Resolution, Conflict, Setting, Point of View, Theme, Style, Tone, Figurative Language, Irony, Sound devices, Rhythm, meter, Alliteration, Simile, Metaphor, Analogy, Personification, Onomatopoeia, Sensory details, specific details, Hyperbole, Imagery, Symbolism, Jargon, Dialect, Slang, Cause and effect, Author's purpose, Foreshadowing, Style, Colloquialism , Connotation, Denotation, Thesis sentence, Main idea, Conclusion, Support, Rhetorical device, Stylistic device, Elaboration, Reliability, Primary source, Secondary source, Works Cited, Organizational strategy, Syntax

Mel-An Individual and His Government Unit

In this unit, students will explore the relationships between an 'Individual and His Government'. Students will learn about the causes and effects of a revolution, the power of propaganda and persuasion, and the stylistic, literary techniques used to persuade, symbolize, and satirize within a novel. The core novel is Animal Farm by George Orwell. The literature circle books also take a look at a variety of individual/government relationships. The literature circle choices are Red Scarf Girl, Zlata's Diary, Katarina, Maus 1 and 2, The Diary of Anne Frank, and Among the Hidden. The writing foci for this quarter are a persuasive essay and a compare/contrast paper.

Stage 1—Desired Results

Established Goals:

Write a multi-paragraph persuasive essay with supporting details/examples.
Write a comparison /contrast paper with a strong controlling idea, supporting and concluding sentences, and logical sequence.
Explore how each individual has a relationship with his/her government.
Analyze the manipulation tactics used in order to persuade others to think/behave in a certain way.

Enduring Understandings: U

Students will understand that…
Every individual has a relationship with his/her government.
People commonly use manipulation tactics in order to persuade others to act a certain way.
Novelists often provide insights about the human experience through fictional means.
Writers use a variety of stylistic techniques to engage and persuade their readers.

Essential Questions: Q

How do people twist words/ideas around in order to persuade others to act in a certain way?
What is the relationship between an individual and his/her government?

Students will know… K

propaganda techniques, including bandwagon, name-calling, testimonial, transfer, etc.
figurative language in fictional text: metaphor, hyperbole, imagery, and symbolism
differences between fact and opinion
a variety of note-taking methods to organize information
pre-reading strategies to aid in comprehension, including, access prior knowledge, predict, and preview
during-reading strategies to aid in comprehension, including self-question and correct, infer, and visualize
post-reading strategies to aid in comprehension, including question to clarify, reflect, analyze, draw conclusions, summarize, and paraphrase
decoding strategies to problem-solve unknown words when reading
comma rules for punctuating various sentence structures
correct use or colons in business letter salutations
proper capitalization for titles of newspapers, magazines, songs, works of art, etc.
causes and effects of a revolution
various literary elements within a work of literature (symbolism, persuasion)
various genres within a literary work (novel, fable, satire)

roles within a literature circle

Students will be able to… S
summarize author's ideas
make predictions
make inferences
evaluate the accuracy, reliability, and relevance of information
sequence events

compare and contrast:
information and relationships in various fiction and nonfiction works text ideas and own experiences text ideas and the work by analyzing the relationship between literature and a historic period and culture
identify and explain cause and effect relationships
create appropriate graphic organizers to provide structure for information
apply writing process to write effectively in various forms and types of writing
address the same topic from two points of view using appropriate form
write a multi-paragraph persuasive essay with supporting details/examples, and evidence that readers' arguments and concerns have been anticipated and addressed
draw conclusions and form opinions
draw from a variety of sources
write a comparison/contrast paper with a strong controlling idea, supporting and concluding sentences, and logical sequence
identify and explain media techniques used to convey messages in various media
use dictionary, spell-check, and other resources to spell correctly
edit and proofread communications
participate in literature circle
identify and analyze figurative language, tone, setting, conflict, characterization in a novel

Stage 2—Assessment Evidence

Performance Tasks: T

The performance task for this unit is to write a persuasive essay.
Students will explore a variety of controversial topics, choose one, and write a compelling, persuasive argument on the topic.
In the paper, students will provide supporting details/examples, and evidence that the readers' arguments and concerns have been anticipated and addressed.

Students will share their persuasive papers in a group and give a short, oral presentation to the class.

Other Evidence: OE

Journal grade, based on five free writing assignments, daily "Do Now" activities, and grammar and usage focus lessons.
Assessments for each step in the writing process: graphic organizers, drafts, and revisions.
Students will include a visual representation of their paper, including photos, graphic organizers, and/or other artifacts of their choice.

Teacher and student self-evaluations for the completeness and effectiveness of each step in the writing process.
Literature circle participation grades, using the group assessment sheet, which includes contribution points for each role: clarifier, illustrator, language master, questioner, connector, recorder, and/or independent reading project – see link:
http://www.mshogue.com/ce9/Ind_novel/logs.htm#Advice%20column

Stage 3—Learning Plan

Learning Activities- Considered the WHERETO elements LW
Post essential questions and enduring understandings, and students record them in their journal.
Complete a journal entry, in which they write what they think the questions and understandings mean.
Discuss the culminating unit performance task: the persuasive essay.
Also, introduce the visual piece, in which student will create a visual representation of their paper.
Explore the persuasive angle of this unit by introducing common propaganda techniques to the class through television ads and magazine ads.
In a think-pair-share format - then a larger group format - create definitions for the terms propaganda, satire, fable, revolution, and utopia.
Students record their working definitions in their journals.
Apply pre-reading strategies to aid comprehension with the following methods: access prior knowledge, preview, predict, and set a purpose and rate for reading.
H
Using websites and/or television footage, explore the facets of a revolution and their prevalence throughout history and today.
Show popular television advertisements and have students respond to them in a journal.
Introduce completed teacher and student persuasive essays.
As a class, discuss positives and negatives of the samples. Brainstorm possible revisions, etc.
In their journals, students will participate in a "write around" group activity, brainstorming controversial issues related to school life (i.e. school uniforms, soda at lunch, etc.).

E
Introduce Animal Farm and the Russian Revolution.
Write journal entries making predictions about what the novel will be about.
Read other persuasive essays with supporting details/examples, and evidence that readers' arguments and concerns have been anticipated and addressed.
Brainstorm a student-generated list in composition notebooks on possible controversial topics for upcoming persuasive essays.
Conduct class discussions about controversial topics and make connections to self, world, and text.
Review the term "propaganda," and show examples of the various types, including assertion, bandwagon, glittering generalities, lesser of two evils, name calling, pinpointing the enemy, plain folks, simplification, testimonials, and transfer.
Then have students find their own examples with in the Animal Farm novel and also in everyday advertisements.
Introduce/review the concept of symbolism.
Have students pinpoint examples of symbolism in the Animal Farm.

Conduct grammar mini-lessons on capitalization, comma usage, and colons in salutations.
Homework review sheets can be used.
Create a word wall for recurring literary terms and unknown vocabulary.

Write down most important terms in the student-made glossary (in composition notebook).
Use problem-solving strategies for unknown words, including roots and affixes and context clues.
Use a variety of teacher-selected texts and guided class discussion to introduce and practice prediction, inference, sequence of events, and cause-and-effect.
Students will journal on how each of these is related to Animal Farm and/or the persuasive essay.
Throughout the novel, create a timeline of events to summarize the plot.
Then have students use the timeline to tell the same story from citizens' and government's point of view.
Both timelines should be recorded in the composition notebooks.
Give students scoring guides for the persuasive essay and compare/contrast paper.
Explain the specific expectations of both assignments.
Allow students to ask questions.
Various technology software programs will be used throughout the unit, including SmartNotebook, SmartIdeas, PortaPortal, the school server, etc.

R
Revisit past journal entries and reflect on how perceptions have changed
Review the unit's vocabulary words through discussions, bell-ringer assignments, vocabulary games, etc.
Have students present their persuasive essays to their classmates through small group discussions and a brief, oral presentation to the whole class.
Revisit EU's and EQ's in class conversations and journal writings.
Students will describe how their perceptions are different now than at the beginning of the unit.
Watch and discuss the animated, video version of Animal Farm.
Make comparisons and contrasts with a graphic organizer.
Explore persuasive essay topics and develop them with a graphic organizer for the essay through class brainstorming, note taking, or other prewriting methods.
Apply post-reading strategies to comprehend and interpret text using the following methods: questions to clarify, reflect, analyze, draw conclusions, summarize, and paraphrase.
E
Take a quarterly benchmark assessment that includes constructed-response and selected-response questions on reading comprehension, themes, ideas, and vocabulary.
Persuasion will be the basis, and a "performance event" will also be part of this assessment.
Share final persuasive essays with visuals in a small group setting.
Students will also give a short, oral presentation, explaining their topic, their opinion, the opposing argument, and process.
Complete a literature circle participation sheet, in which students evaluate their own performance and understanding of the expectations of the literature circle.
Demonstrate understanding of the themes of this unit through literature 'book chats', in which students share ideas, opinions, like and dislikes, and recommendations for book choices.