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Designing for Knowledge Building: An Action Research Study in an Elementary Classroom

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Designing for Knowledge Building: An Action Research Study in an Elementary Classroom

by

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Abstract

This study sought to better understand knowledge building as defined by Scardamalia and Bereiter (2003) as "the production and continual improvement of ideas of value to a community, through means that increase the likelihood that what the community accomplishes will be greater than the sum of individual contributions and part of broader cultural efforts" (p. 1370). This study, which was carried out in a grade three and four classroom, was bound by the following research question: What learning designs enable a class of students to engage in knowledge building?

I employed practitioner action research as a methodological approach to examine, critically question, and transform my understandings of my practice, how I conduct my practice and the conditions under which I practice (Kemmis et al., 2014). Sources of evidence included samples of computer supported collaborative work, documents, observations and journals.

Designs for knowledge building included the use of hooks to elicit real ideas and authentic questions from students, ongoing reference to knowledge building principles as defined by Scardamalia (2002), scaffolds to support student discourse, both face-to-face and online, and the use of Google Applications for Education (GAFE) as a networked space to support sharing and feedback for improving ideas.

The outcomes of this research suggested that students did, with the support of scaffolds, engage with knowledge building principles, worked as a community to improve ideas of value to the community and used GAFE in support of the work of knowledge building. Findings of this study support an ongoing understanding of how both a teacher and a group of students new to knowledge building advance in their effort to continually improve ideas as a community.

Recommendations for further research include: 1) how a culture for knowledge building might continue to shift in a classroom over time; 2) how those students with some experience in knowledge building might support those new to knowledge building; and 3) how the Social Infrastructure Framework (Bielaczyc, 2006, 2013) can support in the design for knowledge building.

Key Words: Knowledge building, distributed cognition, computer supported collaborative learning, culture; Google Applications for Education

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Chapter 1

Introduction

This study sought to better understand knowledge building as defined by the educational researchers Scardamalia and Bereiter (2003) as "the production and continual improvement of ideas of value to a community, through means that increase the likelihood that what the community accomplishes will be greater than the sum of individual contributions and part of broader cultural efforts" (p. 1370). The purpose of this practitioner action research was to better understand how to design for knowledge building by grade three and four children in an elementary school classroom. This work allowed for new insights into practices and practice architectures for me as the teacher-researcher, for my students, and for my colleagues as observations from the work were shared, questioned and discussed. In this work, practice was defined as

> a socially established cooperative human activity in which characteristic arrangements of actions and activities (doings) are comprehensible in terms of arrangements of relevant ideas in characteristic discourses (sayings), and when the people and objects involved are distributed in characteristic arrangements of relationships (relatings), and when this complex of sayings, doings and relatings 'hangs together' in a distinctive human social project. (Kemmis, McTaggart & Nixon, 2014, p. 50)

Practice architecture worked hand-in-hand with practice and included the mediating preconditions that shape practices including cultural-discursive (language, ideas), material-economic (objects, spatial arrangements) and the social-political arrangements (relationships between people) (Kemmis et al., 2014).

This chapter begins with a summary of the background that framed this particular study, followed by the problem statement, the statement of purpose and the research questions. Additionally, this chapter provides a synopsis of the research approach, along with my perspectives and assumptions as the teacher-researcher. Concluding the chapter is a brief discussion regarding the rationale and significance of the study and key terminology used throughout.

Background

In 2009, the Government of Alberta created opportunities for citizens to gather, both in person and online, to discuss their "hopes, dreams and aspirations for K-12 education in the 21st century and beyond" (Alberta Education, 2009, para. 5). From these discussions, the following framework was created to describe the long-term goals for education in Alberta (Alberta Education, 2011).

Figure 1.1. Framework for Student Learning in Alberta (Alberta Education, 2011)

Included with this framework was the recommendation that "the kindergarten to grade twelve (K-12) school system should strive to instill the following qualities and abilities in our youth” (Alberta Education, 2009, p. 5): engaged thinkers, ethical citizens and entrepreneurial spirit.

Of particular interest for this research is the definition developed by the steering committee of the engaged thinker as one:

> who thinks critically and makes discoveries; who uses technology to learn, innovate, communicate, and discover; who works with multiple perspectives and disciplines to identify problems and find the best solutions; who communicates these ideas to others; and who, as a life-long learner, adapts to change with an attitude of optimism and hope for the future. (Alberta Education, 2009, p. 6)

Simply stated, the engaged thinker would describe herself as a person who “collaborate(s) to create new knowledge” (Alberta Education, 2009, p. 19).

In and around the same time, Friesen (2009) released the report entitled, *What Did You do in School Today?* The result of an initiative launched in 2007 between Canadian Education Association (CEA), Galileo Education Network and the Learning Bar Inc., this report was “designed to capture, assess and inspire new ideas about enhancing the learning experiences of adolescents in classrooms and schools” (Friesen, 2009, p. i). Key to this report is the suggestion that, if schools are to exist in a knowledge society, they have to change; these changes require “a radical break with the past that requires us to stop and completely rethink much of what we do” (Gilbert, 2005, p. 10). Specifically, what we know is less important than what we are able to do with knowledge in different contexts; our current notions of knowledge, mind and learning requiring reconceptualization (Gilbert, 2005).

With this rethinking of education in the knowledge age, Alberta Education (2009) addressed the important role of technology, as educators work toward instilling the qualities of the engaged thinker in all students. Specifically,

> if [educators} are to shape the future of education and not have it shaped for us, [educators] must become more purposeful in our approach to technology. [Educators] need to understand what may be emerging, its implications, and how it can be used for education. Ultimately, the power of technology should be harnessed to support innovation and discovery, not simply to aid teaching. (Educators) need to engage learners to use these new technologies as designers and creators of knowledge. (Alberta Education, 2009, p. 29)

As a follow up to this assertion, Alberta Education (2013) published the *Learning and Technology Policy Framework*. The intention of this framework, including a set of principles, policy directions, outcomes, and actions, is to support government and school authorities in visioning, planning and decision-making related to technology. Five interrelated policy directions are identified as the core of the framework:

- Student-Centered Learning: technology is used to support student-centered, personalized, authentic learning for all students.
- Research and Innovation: teachers, administrators and other education professionals read, review, participate in, share and apply research and evidence-based practices to sustain and advance innovation in education.
- Professional Learning: teachers, administrators and other education professionals develop, maintain and apply the knowledge, skills and attributes that enable them to use technology effectively, efficiently and innovatively in support of learning and teaching.

- Leadership: education leaders establish policy and governance structures, cultivate innovation and build capacity within the system to leverage technology in support of student-centered learning and system efficiencies.
- Access, Infrastructure and Digital Learning Environments: students, teachers, administrators and other education professionals have access to appropriate devices, reliable infrastructure, high-speed networks and digital learning environments. (Alberta Education, 2013)

This framework positions technology as an enabler, one that plays an integral role in development of students as future global citizens (Alberta Education, 2013).

One key technology that has emerged in educational settings is that of cloud computing. In the New Media Consortium (NMC) 2014 Horizon Report, the authors suggest that cloud computing will be rapidly adopted into K-12 practice with a time to adopt horizon of one year or less (Johnson, Adams-Becker, Estrada & Freeman, 2014). The report further suggests that cloud computing supports collaboration with the use of software as a service (SaaS), such as Google Applications for Education (GAFE) (Johnson et al., 2014). This has been true in the local setting where this research took place, as there has been a system wide adoption of G Suite for Education (formerly Google Apps for Education or GAFE), described by the system as “an engaging online environment for students and teachers to create and collaborate on lessons and projects” (Calgary Board of Education, 2017a, n.p.). All students are provided access by way of enrolment in the school system.

Most recently, a curriculum redesign was recommended and subsequently initiated in response to the desired educational changes in Alberta. In past years, Alberta's curriculum was developed one subject at a time and over different time periods, resulting is no common design across subject areas. The work currently in progress includes changes to design, content, and the processes used to develop curriculum in effort to assist teachers in planning with a focus on competencies, literacy and numeracy grounded in subject content (Alberta Education, 2017).

In October of 2016, working groups, composed of teachers, Alberta Education staff, and post-secondary instructors began drafting future curriculum in Language Arts, Mathematics, Social Studies, Science, Arts and Wellness Education (Alberta Education, 2017). The intention behind the structure and design of the new curriculum is to:

- provide opportunities for depth of learning and understanding
- present cross-curricular approaches to learning through competencies and literacy and numeracy that transcend subjects
- go beyond ‘learning about’ to learning the ways of knowing, doing and being and acknowledging that ideas need to be brought into relationship with each other
- make connections within and outside of the school or the subject
- require, respect and sustain multiple ways of know that individuals, communities and cultural groups may hold. (Alberta Education, 2017)

While Alberta Education determines what students need to learn, teachers are tasked with using their professional judgement to determine how students achieve the learning outcomes in the curriculum (Alberta Education, 2017).

Confronted by educational changes such as those noted above, Kemmis et al. (2014) suggest that educators need to ask whether and how their teaching designs and practices might need to change so they will be more educational. This means asking whether current practices, and the practice architectures of our educational institutions, unreasonably limit and constrain:

1. the way people (for example, teachers, students, administrators, community members) *understand* things, and their opportunities for individual and collective *self-expression*
2. the way people are able to *do* things, and their opportunities for individual and collective *self-development* and
3. the ways people are able to *relate to one another and the world*, and their opportunities for *self-determination* (emphasis in original). (Kemmis et al., 2014)

As a teacher with more than 20 years of experience in various school settings, my practices are informed by the importance of "the active creation of mental structures, rather than the passive internalization of information from others or from the environment" (Nathan & Sawyer, 2014, p. 24-25). I concur with Sawyer (2014) who contends that when children actively engage in constructing their own understandings, they gain more generalizable knowledge, comprehend more deeply and demonstrate increased motivation to learn. I have seen this come alive in my own classroom as my students are consistently invited into problem-based and inquiry approaches to learning, and are motivated to learn.

Entering into this study, my current practice was in keeping with what Scardamalia and Bereiter (2002b) suggest as a middle-level constructivist approach, whereby students engage somewhere between the extremes of shallow and deep constructivism, with greater or lesser engagement with ideas or greater or lesser amounts of responsibility in the processes. I questioned whether this level of student engagement was enough to meet the initiatives set out by the provincial government and I wondered whether a shift in my own practices was necessary. This shift involved moving forward for knowledge building, as a way to address this contemporary emphasis on knowledge creation and innovation (Scardamalia & Bereiter, 2006).

Knowledge building "represents an attempt to refashion education in a fundamental way so that it becomes a coherent effort to initiate students into a knowledge creating culture" (Scardamalia & Bereiter, 2006, p. 97). As defined by Scardamalia and Bereiter (2003), knowledge building is "the production and continual improvement of ideas of value to a community, through means that increase the likelihood that what the community accomplishes will be greater than the sum of individual contributions and part of broader cultural efforts" (p. 1370). In this sense, *knowledge*, rather than being considered a static mental structure inside the learner's head, is a series of social constructions that are unavoidably partial, incomplete and biased (Davis, Sumara & Luce-Kapler, 2015). Knowledge building calls for deep constructivism at all levels of education and this leads to innovation (Scardamalia & Bereiter, 2002). This practitioner action research study sought to explore what it entails, for me, me as a classroom-based teacher to move a group of elementary students forward in knowledge building.

Problem Statement

Despite my personal efforts to engage students beyond passive internalization of information (Nathan & Sawyer, 2014), as a classroom teacher I continued to see many students engage in more surface rather than deeper levels of understanding. Students continued to see knowledge as something to borrow rather than as “building a personal understanding of the models they (need) to make personal sense of complex phenomena” (Schwartz & Fischer, 2003, p. 4). When working together using networked technologies, students tended to approach tasks as cooperative activities, whereby “partners split the work, solve sub-tasks individually and then assemble the partial results into the final output” (Dillenbourg, 1999, p. 8), resulting in individual learners’ limited understanding of the whole. As a teacher-researcher, I sought to improve my own practice by way of exploring a knowledge building approach with my students in the hopes of achieving deep constructivism for students as posited by Scardamalia and Bereiter (2002b).

Statement of Purpose and Research Questions

The purpose of this practitioner action research study was to explore, as a teacher-researcher, how to engage students in knowledge building in an elementary school classroom. The following research question bound this study: What designs enable a class of students to engage in knowledge building? Originally, the study further involved the following goals of understanding: a) how students engage with the knowledge building principles as defined by Scardamalia (2004); b) the quality of scaffolded discourse in computer supported collaborative environments, whereby students are provided with a scaffolds in the form of written prompts, including ‘My theory is…, I need to understand…, A better theory is…, This theory does not explain…, Putting our knowledge together…’ to support their contributions to the CSCL environment; c) the resources of the literate learner in moving forward for knowledge building; and d) the beliefs about knowing and knowledge, referred to as epistemic cognition, that students bring into knowledge building experiences. However, during the course of the school year, the study shifted in focus and reasons for this shift are discussed in detail throughout this work. Here, it suffices to say that this study sought to better understand the following: What learning designs enable a class of students to engage in knowledge building? The study evolved further to focus on understanding: a) how students engage with the knowledge building principles as defined by Scardamalia (2004); b) the quality of scaffolded discourse in computer supported collaborative environments; and c) the relationships that exist between knowledge building and design thinking.

Research Approach

This study engaged a practitioner approach to action research, defined in further detail in chapter three. After concerns were identified in an initial stage of the research referred to as reconnaissance, this action research approach involved an iterative cycle of planning, acting, developing and reflecting. This cycle is illustrated in Figure 1.2.

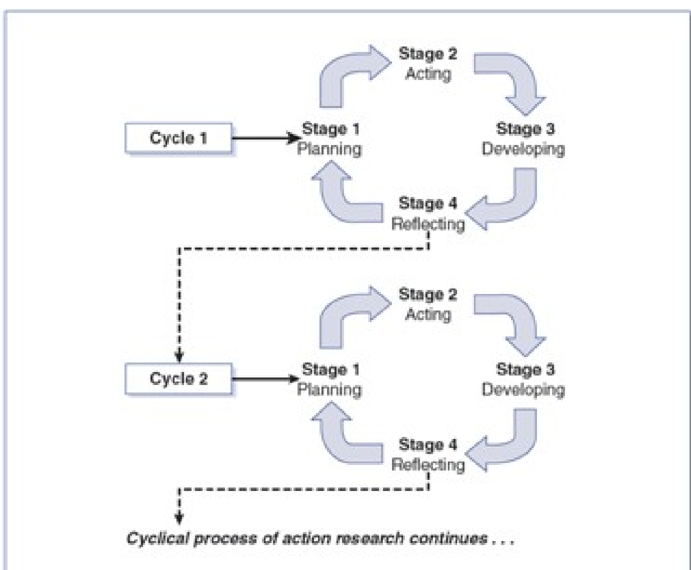


Figure 1.2. Action research cycle (Mertler, 2014)

Reconnaissance stage. Reconnaissance is a way of "exploring the felt concerns experienced by different people and groups involved in and affected by practice"

(Kemmis et al., 2014, p. 86). Reconnaissance is unique to action research and is the process of gathering preliminary background information. Formal reconnaissance can take three forms: self-reflection, description and explanation.

- Self-reflection on one's own understanding of and values regarding education.
- Formal description the situation or problem that will serve as the focus of action research.
- Explanation as to why the problem is occurring, and development of a hypothesis about the potential outcome of an action research study. (Mertler, 2009)

This reconnaissance stage led me to examine the current initiatives in education, along with my own current practices and the supporting practice architectures in relation to these initiatives, as noted earlier as background. Consideration of these factors, along with dialogue in communicative spaces in the work place and in the doctoral cohort, led to defining the problem, the research questions and the planning stage.

Planning stage. This reconnaissance stage led to a planning stage in deciding what first steps to take towards transforming practices, understanding practices and the conditions under which we practice; it involved thinking about what I, as the teacher-researcher, could do to make my practices more educational (Kemmis et al., 2014). This planning stage involved gathering information and reviewing related literature, the results of which are presented in chapter two. Further to this, the planning stage involved developing a plan for change and for how best to observe and document the conduct and consequences of the changes. These plans are presented in chapter three as the initial approaches to evidence collection and analysis.

Collection of evidence involved a) ongoing collection of knowledge building discourse, as supported by scaffolds, from the computer supported collaborative learning environment; b) semi-structured observations regarding knowledge building principles as defined by Scardamalia (2006), and c) teacher-researcher reflective journaling to monitor thinking and actions as well as how thinking has informed actions.

Analysis included a) narrative analysis (Fu, van Aaslt & Chan, 2013) of computer supported collaborative learning discourse; b) first and second cycle in vivo coding of observations and reflections; c) first and second cycle descriptive coding of observations using the knowledge building principles; and d) first and second cycle descriptive coding of observations using the Social Infrastructure Framework (Bielaczyc, 2006).

Acting and observing stage. From here, the practitioner action research approach involved enacting the plan, collecting data, analyzing data and then redesigning. This iterative process occurred from October, 2016 to May 2017.

Reflecting stage. This stage focused on working out what the next steps might entail, followed by, once again enacting and reflecting. Reflection involved considering the consequences of the actions, including anticipated and unanticipated effects, intended and unintended effects and side effects (Kemmis et al., 2014). This iterative approach occurred over the course of the school year in as many cycles that the time frame allowed.

Assumptions

The following assumptions underscored this action research project. Individual teachers are able to determine the nature of an investigation to be undertaken. Action researchers are capable of choosing their own areas of focus, determining plans for conducting the research, and developing action plans based on their findings. In committing to action research, there exists a commitment to continual professional development and school improvement through a process of critical reflection (Gay, Mills, & Airasian, 2009).

The Researcher

I came into this study as an experienced classroom-based teacher, who had taught kindergarten to post-secondary aged students. My teaching experience included a high level of diverse learners in both regular and specialized settings. I brought to the research an extensive repertoire of teaching and learning experiences connected to the social, emotional and academic needs of learners. I believed, and still do, that continually exploring how to create strength-based practices is one of the most intriguing and essential parts of teaching. The opportunity to research, collaborate and to find ways to maximize the potential of all students was, and continues to be, foundational to my pedagogical passion.

As a beginning researcher, I understood that my beliefs influenced the research process. I believed, and continue to believe, that we "construct knowledge through our lived experiences and through our interactions with other members of society. As researchers, we must participate in the research process with our subjects to ensure we are producing knowledge that is reflective of their reality" (Lincoln, Lynham & Guba, 2011, p. 103). Entering into this work, I acknowledged that we are shaped by our lived experiences, and these will always come out in knowledge we generate as researchers and in the evidence generated by our participants (Lincoln et al., 2011).

I recognized that these experiences and beliefs are both of value and potential liability. It is for these reasons that I acknowledged them in advance of the research. To strengthen the trustworthiness of the research, or more specifically, the credibility and dependability, triangulation of sources of evidence was employed. I acknowledged that those working in the vein of interpretive research struggle with terms such as trustworthiness, credibility, dependability and triangulation (Altheide & Johnson, 2011). However, these words continue to appear in current literature on action research (Kemmis, McTaggert, & Nixon, 2014; Mertler, 2016; Parsons, Hewson, Adrian & Day, 2013) and so, in an attempt to move beyond these more positivist views, I further commit to critical reflection on the consequences of my actions, the pragmatics of my practice, and the different ways of knowing by way of on-going journaling as a further attempt to deal with the larger issues of truthfulness and validity within the field of action research (Altheide & Johnson, 2011).

Rationale and Significance

"The aim of all research is to generate knowledge, something that was not known before, and to demonstrate the validity, or believability, of this knowledge" (McNiff & Whitehead, 2009, p. 19). The rationale for this study emanated from my desire, as a teacher, to improve my own practice by continually generating knowledge and to engage in progressive problem solving with the goal of surpassing past achievements (Scardamalia & Bereiter, 1993).

It was anticipated that, through this work, a) my own practice would improve as I developed a better understanding of the role of the teacher in the knowledge building process; b) students would have opportunity to engage in knowledge building in a computer supported collaborative learning environment; and that c) I would have an opportunity to share my story in the hopes of informing others.

Key findings included the following. When considering the designs for knowledge building in this action research, the findings support that students were able to advance in knowledge building as they worked together to improve ideas of value to the community. Further, students engaged with knowledge building principles with varying degrees of frequency as a result of the designs implemented over the course of the school year. Over time, scaffolded discourse in GAFE shifted in its purpose as students took up the work of knowledge building. Additionally, design thinking allowed further opportunities for students to continually improve ideas, supporting a further enculturation into knowledge building.

During and by the conclusion of this study, I would contend that my own practice improved in that I became more reflective of my sayings, doings and relatings, especially in regards to designing for knowledge building and I saw evidence of student knowledge building in many different ways. Further to this, all students had ongoing opportunities to engage in knowledge building, with shifts in how they conceived knowledge, learning, their own roles in the classroom and the roles of others based on the evidence collected and analyzed. These reflections were shared among colleagues throughout the year by way of teacher planning, implementing and reflecting in teams and in a whole school setting. As a result off this sharing, I noted shifts in the practices of my colleagues.

Operational Definitions

The following key terms are used throughout this dissertation. Therefore, I have provided operational definitions to inform and guide the reader.

Computer supported collaborative learning. Situations in which computer technology plays a significant role in shaping collaboration, either when learners are at a distance or co-present (Goodyear, Jones, & Thompson, 2014).

Culture. Layers of knowing that operate at the collective level, comprised of the history of thinking, customs, languages, artifacts (Davis et al., 2015).

Design Thinking. Process as a system of overlapping spaces: inspiration, ideation, and implementation. (Kelly, 2016)

Knowledge building. The “production and continual improvement of ideas of value to a community, through means that increase the likelihood that what the community accomplishes will be greater than the sum of individual contributions and part of broader cultural efforts” (Scardamalia & Bereiter, 2003, p. 1370).

Learning. Doing something to alter the state of your mind to achieve a gain in personal knowing or competence (Bereiter, 2002).

Narrative analysis. Data analysis technique whereby the “aim is to explain why and how something has happened by means of configuring a series of sequential events that are consequential for what happened” (Fu, van Aalst, & Chan, 2013, p. 32).

Practice. A socially established cooperative human activity in which characteristic arrangements of actions and activities (doings) are comprehensible in terms of arrangements of relevant ideas in characteristic discourses (sayings), and when the people and objects involved are distributed in characteristic arrangements of relationships (relatings), and when this complex of sayings, doings and relatings ‘hangs together’ in a distinctive human social project (Kemmis et al., 2014, p. 50).

Practice architecture. The mediating preconditions that shape practices including cultural-discursive, material-economic and the social-political arrangements (Kemmis et al., 2014)

Technological affordances. “Temporal relationships between human and technological actors within networked social environments” (Parchoma, 2014, p. 367).

Chapter 2

Literature Review

Toward the end of the twentieth century, government spending on information technology, for the first time in history, exceeded spending on industrial age capital goods such as engines, mining, oil fields and agriculture; it was this shift in spending that became recognized as the beginning of the ‘knowledge age’ (Trilling & Hood, 1999). While some suggest that the industrial age work will never go away, it will conceivably fade to lower levels with a simultaneous increase in knowledge work (Trilling & Hood, 1999).

The proliferation of new terms such as knowledge age, knowledge economy, knowledge revolution and knowledge work allows opportunity to reconsider the meaning of the word ‘knowledge’, specifically what it is, how it develops how it is used, what it is used for, and who owns it (Gilbert, 2005). Former conceptions that situate knowledge as ‘stuff inside the mind’ no longer serve a world where what we know is less important that what we are able to do with knowledge in different contexts and where our capacity for learning outweighs the importance of our ability to follow rules (Gilbert, 2005). Recognizing the complexity this holds for teachers, Friesen (2009) suggested that a paradigm shift in how we think about knowledge will require teachers to define, create, assess and redesign in effort to create effective learning environments in which students inquire into questions, issues and problems, build knowledge, and develop deep understanding that goes well beyond the focus on memorizing facts. This paradigm shift includes practices that are more collaborative and community-focused (Friesen, 2009).

Further, the emergence of the ‘knowledge age’ has necessitated a need for students to understand how to work with ideas (Bereiter, 2002). A focus on knowledge building, in that it places the continual improvement of ideas at the center of the learning community, allows for such a paradigm shift (Tarchi, Chuy, Donoahue, Stephenson, Messina & Scardamalia, 2013).

The purpose of this chapter is to examine current literature relating to a knowledge building approach and how a teacher might design for such. The review explores: a) what is meant by the term, ‘knowledge’; b) what are the key characteristics, principles and theories underpinning the concept of knowledge building; c) what is the relevance of technology to the knowledge building process, specifically computer supported collaborative learning (CSCL) and c) where do we find current educational initiatives in design thinking and what is the relevance to knowledge building. Further, this review will seek to uncover gaps in the research and identify opportunities for further investigation based on those gaps.

What is Knowledge?

Before exploring what it means to become a knowledge builder, it is important to understand the word *knowledge* and particularly what is meant by or how is knowledge defined in this work. Epistemology, the branch of philosophy that investigates the origin, nature, methods and limits of knowledge, involves varying positions in regards to the acquisition of knowledge: objectivism, pragmatism and interpretivism (Hofer & Pintrich, 1997). Objectivists posit knowledge as true and absolute, pragmatists regard knowledge as a worthy but improbable goal, and interpretivists suggest that knowledge is constructed at an individual level (Hofer & Pintrich, 1997).

Redefining knowledge is key in advancing the work being done in schools to best prepare students for the knowledge age (Bereiter, 2002; Gilbert, 2005).

According to Gilbert (2005),

> educationists do not have a single, coherent theory of knowledge. We don't have an agreed-on way to decide what we think knowledge *is* – how we think it develops, what good knowledge is, and so on. Instead we have a hotchpotch of assumptions and ideas that, because they come from different philosophical traditions, often conflict. (p. 147)

Knowledge was, at one time, the province of philosophers, who talked about what it was, how it developed and who framed it as justified, true belief (Gilbert, 2005). Sociologists began to study knowledge in the 1970's, from the point of view of the people who create and value knowledge, using terms such as explicit and tacit knowledge (Nonako, 1994). More recently, cognitive psychologists have taken on the work of framing knowledge, using terms such as procedural, propositional, declarative, prior, individual and social knowledge (Greene, Sandoval & Bråten, 2016).

Bereiter (2002b) argued that this cognitive perspective of knowledge, specifically the dichotomy of declarative and procedural knowledge, is highly valued in school as it is observable. Bereiter (2002b) moved beyond this dichotomy and offered special attention to other forms of personal knowledge: statable knowledge, implicit knowledge, episodic knowledge, impressionistic knowledge, skill, and regulative knowledge.

Statable knowledge is knowledge that the knower can put into some explicit form such as sentences, diagrams or stories. It can be conveyed, argued about, compared or evaluated. It is essentially declarative knowledge (Bereiter, 2002).

Implicit understanding, Bereiter (2002b) explained, is knowledge that people have but that they cannot state. It is knowledge gained from experience as opposed to knowledge gained from a book; it is a “sort of residue of past experiences” (Bereiter, 2002, p. 139). This might also be referred to as tacit knowledge.

Episodic knowledge includes remembered episodes or memories of events. These remembered episodes can be retrieved and considered in new contexts (Bereiter, 2002). Bereiter (2002b) argued that there is little doubt that the recall of past experiences is an important part of a mind that is knowledgeable.

Impressionistic knowledge includes feelings and impressions that influence actions; these thoughts and feelings function like knowledge even though they are not considered as such. Impressionistic knowledge is also the stuff of prejudices, phobias or crazes (Bereiter, 2002).

Skill is closely related to procedural knowledge. It is ubiquitous in that, no matter what, if something is done repeatedly, a person will become more skilled at doing it, either correctly or incorrectly. These changes in skill that take place with practice are defined as learning, according to Bereiter (2002b).

Regulative knowledge is the understanding of self as a learner or the knowledge that pertains to the learner as a factor in the activity. How to manage oneself, shepherd mental, physical or emotional resources all fall into this form of knowledge (Bereiter, 2002).

Bereiter (2002b) argued that, when students hold misconceptions, simply addressing statable knowledge and skill might not be significant enough to alter these misconceptions. Bereiter (2002b) further suggested that students might not recognize their misconceptions if only statable knowledge and skill are addressed. It is important to bring about change in the implicit understanding or knowledge gained from experience to address the misconceptions (Bereiter, 2002). Further, competency in any domain would require all forms of knowledge, not just declarative or procedural (Bereiter, 2002).

Bereiter (2013) also discussed principled practical knowledge. He suggested that this type of knowledge includes both the ‘know how’ and the ‘know why.’ Specifically, it is both declarative and procedural in that it is knowledge of how to achieve practical objectives but it is also knowledge that can be communicated symbolically, argued about, combined with other propositions to form larger structures (Bereiter, 2013). Principled practical knowledge guides practice as opposed to explaining or predicting; it grows out of an effort to produce new knowledge, going beyond what is required for a task but not so far beyond that it is unusable by most (Bereiter, 2013).

In education, the predominant epistemological stance of knowledge, which comes from the standardized model of education, defines knowledge as external, statable, and objectively real (Davis et al., 2015). It is seen as something that starts on the outside of one’s head and somehow manifests inside one’s head (Davis et al., 2015). In this epistemological stance, the mind is seen as a container and learning is the process of storing knowledge in the container (Bereiter, 2002; Gilbert, 2005). This metaphorical understanding of ‘knowledge as an object’ is “ancient and became a part of a cultural common sense long ago” (Davis et al., p. 29). Gilbert (2005) suggested moving away from this stance that sees knowledge as ‘a thing’ and toward seeing knowledge as “something that does things, something that acts on things to produce new things” (p.

149). As the educational context has changed significantly over time, this current epistemological stance is no longer sufficient (Gilbert, 2005).

Bereiter (2002b) concurred and suggested we must conceive of knowledge as something other than the 'stuff' inside peoples' heads (Bereiter, 2002). "The idea of knowledge as the contents of a mental filing cabinet is…the most stultifying conception in educational thought" (Bereiter, 2002, p. 24). If education is to move forward, we are in need of redefining conceptual tools; the most basic tools are our conceptions of mind and knowledge. Change must start with these conceptions if education is to become unstuck (Bereiter, 2002).

Davis et al. (2015), in exploring the distinctive language in education, discussed the word knowledge, related to changing eras, cultural trends and social movements. In this work, they suggest that

> language preserves a memory of earlier insights while it frames current possibilities…language holds a key for understanding why, for example, today's classrooms look very much like classrooms from a century ago – whereas the structures outside the classrooms from a century ago are so, so different. And that key can unlock new possibilities. (Davies et al., p. 5)

Looking at four historical moments associated with a distinct set of teaching practices, Davis et al. (2015) explained that in the standardized education moment, knowledge is viewed as a commodity and object and, with this understanding of knowledge, learning is framed as acquisition and internalization of these objects (Davis et al, 2015). Over time, personal knowing then came to be framed as an evolving network of ideas; learning was reframed in terms of adaptation (Davis et al. 2015). More recently, knowledge has been framed as social constructions that are unavoidably partial, incomplete and biased distributed among humans with each person participating in a planetary web of knowing (Davis et al. 2015). When considering learning, the power of the collective is recognized as bidirectional, and learning is seen as an ongoing process of revising one's thoughts and actions to fit with the circumstances (Davis et al. 2015).

New metaphors or mental models are needed if we are to better prepare students for this knowledge age (Bereiter, 2002, Gilbert, 2005; Davies et al., 2015)). Knowledge needs to be seen as a verb rather than a noun, something that is fluid and dynamic, a process rather than a product, something used to produce something new (Gilbert, 2005). Knowledge building is an attempt to engage these new metaphors of knowledge, learning and teaching.

Designing for Knowledge Building

This study, as previously noted, was bound by the question, 'What designs enable a class of students to engage in knowledge building?' Goodyear and Dimitriadis (2013) suggested that learning cannot be designed; rather, learning can be designed for. "One cannot design someone else's experience. One cannot design their happiness. One cannot design their learning. Only the person who is learning can learn. Someone in the design for learning can design *things* that help other people learn" (Goodyear & Dimitriadis, 2013, p. 2). More specifically, Mor, Craft and Maina (2015) asserted the following with regards to learning design. Design is:

- A process by which practitioners aim to achieve educational aims in a given context
- An art: a skilled craftsmanship and creative practice

- A science: critical and reflective inquiry informed by theory
- Ethically driven: education strives to make the world better, hence learning design is tasked with understanding what “better’ means and how to get there
- Change-oriented: responding to a changing world, realizing that doing the same thing as before will not achieve the same results – but doing things differently can achieve better results
- Iterative: considering the current state of affairs, perturbing it with innovations, observing the changes that ensue and repeating.
- Interleaving problem-setting and problem solving; as we change the environment in which we operate, our understandings of that environment changes, and consequently so do our desires within it
- Humble: acknowledging the limitations of real world settings, and acknowledging our limitations as actors within those settings. (p. xi)

Mor et al. (2015) contended that, while individual definitions of learning design may vary, most of the experts in the field of learning design would agree with these assertions.

Goodyear, Carvalho and Dohn (2014) suggested that while tasks are designable, and the physical setting and division of labour are partially designable, learning activities and outcomes emerge in response to the tasks, and the physical and social contexts. Design, therefore, entails thinking about the learning places, tools and other resources that students are likely to find helpful, for any particular task, while recognizing that students may not follow the recommendations inscribed in designs. Learners will often make their own choices about tools to use, where to work, what to read, and so forth (Goodyear et al., 2014). What people learn, or the learning outcomes, is an indirect result of the task that has been designed for them (Goodyear et al., 2014). As a result, designing for learning should be activity-centered by providing careful consideration of the relationship between that which has been designed, the subsequent activities and the resulting learning outcomes (Goodyear & Dimitriadis, 2013).

A forward-oriented or pro-active stance is recommended when designing for learning by giving consideration to each of the following phases of design: design for configuration, design for orchestration, design for reflection and design for redesign (Goodyear & Dimitriadis, 2013). It is for analytical purposes that different phases can be identified. However, it is important to note that these phases do not represent a linear or step-by-step process. Rather, the design phases are part of an iterative, ongoing life cycle and for that reason, there is opportunity for multiple entry points (Goodyear & Dimitriadis, 2013). Further, a linear process would necessitate waiting for the end of the process before evaluating the design; using an iterative process such as the one used in this study, means that evaluation may come at any time and at multiple times, thus resulting in multiple feedback loops (Goodyear & Dimitriadis, 2013). These four phases are as follows.

Design for Configuration. Designing for learning is complex as it is often dealing with multiple desired outcomes (Goodyear & Dimitriadis, 2013). In trying to balance the multiple desired outcomes, design for configuration involves the process of designing tasks, environment and organization with respect to a specific context (Dimitriadis & Goodyear, 2013). It further involves considering and planning for contingency in regards to what students and other agents do, and to then to prepare, customize or otherwise modify that which has been designed, to suit specific needs

(Goodyear & Dimitriadis, 2013).

Design for Orchestration. Orchestration refers to the management of multi-layered activities in a multi-constraints context at the time of learning (Goodyear & Dimitriadis, 2013). These constraints may be internal (the content, the learner characteristics and how students build knowledge) or they may be external (time, student behaviour and discipline, curriculum relevance, assessment, teacher and student energy level and space) (Dillenbourg, 2013). In designing for orchestration, it becomes important to consider supports for the teacher in order to adapt the activities in response to the internal and external constraints (Dillenbourg, 2013; Dimitriadis & Goodyear, 2013). Further, in regards to the balance of control, design for orchestration "seeks to find the optimal allocation of regulation among the system and the actors" (Dillenbourg, 2013, p. 486). Design choices are made in such a way that the teacher is not so much a 'conductor' with whom the ultimate decisions rest; rather, orchestration seeks to shift the balance of control toward the system and actors (Dillenbourg, 2013).

Design for Reflection. Design for reflection ensures that actionable data is gathered in real time to inform system evaluation (Goodyear & Dimitriadis, 2013). This reflection can be performed by the student and/or the teacher or automatically by a computer agent and may lead to the implementation of further supports for learning, evaluation, orchestration or even redesign (Dimitriadis & Goodyear, 2013). The designer needs to design with an eye on monitoring appropriate, actionable data, and the potential tools and processes that might support this reflection (Dimitriadis & Goodyear, 2013).

Design for Redesign. Reflection leads to redesign. Design for redesign involves "consciously making design choices at time t, to make modifications at time t + 1 easier"

(Goodyear & Dimitriadis, 2013, p. 4). Good design acknowledges that redesign is the norm rather than the exception (Goodyear & Dimitriadis, 2013). In sum, these four phases of design - configuration, orchestration, reflection and redesign - represent an iterative framework that may support educators in taking a forward oriented stance when taking on design work.

Beyond these assertions and phases of design, a teacher as designer is encouraged to consider that "most effective learning occurs when the learning is situated in an authentic, real world context" (Krajcik & Shin, 2014, p. 277). Within situated learning,

> (k)nowledgeability is routinely in a state of change rather than stasis, in a medium of socially, culturally, and historically ongoing systems of activity, involving people who are related in multiple and heterogenous ways, whose social locations, interests, reasons, and subjective possibilities are different, and who improvise struggles in situated ways with each other over the value of particular definitions of the situation, in both immediate and comprehensive terms, and for whom the production of failure is as much a part of the routine collective activity as the production of average, ordinary knowledgeability." (Lave, 2009, p. 207)

One such approach, which is of key interest for the remainder of this literature review, is that of knowledge building. The following section of this literature review explores the characteristics and principles of knowledge building and, in doing so, seeks to begin to understand what designing might entail in working toward engaging students in knowledge building.

Operationalizing Knowledge Building

The term ‘knowledge building’ was first introduced in an educational context toward the end of the 20th century by Scardamalia and Bereiter (2006). Knowledge building is defined as “the production and continual improvement of ideas of value to a community, through means that increase the likelihood that what the community accomplishes will be greater than the sum of individual contributions and part of broader cultural efforts’’ (Scardamalia and Bereiter, 2003, p. 1370). In short, knowledge building gives students collective responsibility for idea improvement (Scardamalia, 2016). It is this emphasis on collective cognitive responsibility that distinguishes knowledge building from similar activities such as collaborative inquiry or problem-based learning (Zhang, Scardamalia, Reeve, & Messina, 2009).

Knowledge building, which is participatory in nature (Dohn, 2009; Stahl, 2005), seeks to make idea improvement commonplace, universal and enjoyable (Scardamalia & Bereiter, 2010). Knowledge building results in the “creation or modification of public knowledge—knowledge that lives ‘in the world’ and is available to be worked on and used by other people” (Scardamalia & Bereiter, 2003, 1370). Knowledge is framed as social constructions that are unavoidable partial, incomplete and biased; knowledge is distributed among humans with each person participating in a planetary web of knowing (Davis et al. 2015). This is in opposition to those definitions of knowledge during the standardized moment of education as external, statable and objectively real (Davis et al. 2015).

In knowledge building, ideas are considered to be conceptual artifacts (Bereiter, 2002) where “*conceptual* may be understood to refer to discussible ideas, ranging from theories, designs, and plans down to concepts, like unemployment and gravity. *Artifact* conveys that these are human creations and that they are created to some purpose" [emphasis in original] (np). Working with conceptual artifacts rather than on the physical objects to which they are related is what differentiates the knowledge age from the industrial age (Bereiter, 2002).

Underlying Bereiter's work is Karl Poppers' theory of three interacting worlds (Bereiter, 2002). In this, World 1 involves physical artifacts, World 2 entails mental objects or events, and World 3 involves knowledge, ideas or constructed realities (Bereiter, 2002; Hattie, 2013). World 3 is "entirely created by humans, is fallible but capable of being improved, and can take on a life of its own" (Hattie, 2013, p. 26). For Bereiter (2002b), learning is activity directed toward World 2. It is doing something to alter the state of the mind in order to achieve a gain in personal knowledge or competence. Knowledge building is activity directed toward World 3; it is doing something to a conceptual artifact (Bereiter, 2002). World 3 (the knowledge world) stands apart from World 2 (the mental world), suggesting that learning, as an internal or mental process, is unobservable (Scardamalia & Bereiter, 2003) and is separate from knowledge building, an external process (Bereiter, 2002; Reck, 2002). While learning is always a byproduct of knowledge building, the reverse is not necessarily true (Bereiter, 2002; Scardamalia, 2016). The following section of this literature review explores knowledge building in theory and in practice by way of exploring intentionality and community knowledge as defining characteristics. This is then followed by a brief discussion on the various critiques of knowledge building.

Constructivism, Constructionism, and Knowledge Building. Knowledge building is rooted in constructivism (Scardamalia, 2002). Constructivists are interested in the processes by which individuals construct their own knowledge (Halpenny & Pettersen, 2014). von Glaserfield (1990) identified Jean Piaget as "the pioneer of constructivist thinking" (p. 22) and summarized the following principles of constructivism:

- knowledge is not passively received either through the senses or by way of communication;
- knowledge is actively built up by the cognizing subject.
- the function of cognition is adaptive, in the biological sense of the term, tending towards fit or viability;
- cognition serves the subject's organization of the experiential world, not the discovery of an objective ontological reality. (p. 22)

Piaget suggested that children organize their world into cognitive structures called schemata that continually evolve by way of two mechanisms referred to as assimilation and accommodation, resulting in the construction of new knowledge (Halpenny & Pettersen, 2014; Kafai, 2006). When individuals assimilate, they incorporate new experiences into existing schema (Halpenny & Pettersen, 2014). However, when faced with new information that does not fit with existing schemata, the individual is said to be in a state of disequilibrium (McLeod, 2015). As a result, the individual accommodates and existing schemata are restructured to account for new information (Halpenny & Pettersen, 2014). While Piaget did not relate his theory directly to education, others researchers have done so (McLeod, 2015). One such example involves constructivism in relation to complicated and complex learning theories.

To further understand constructivism, a distinction can be made between complicated and complex systems, a distinction that has become an important one in discussions regarding learning, teaching and school (Davis, Sumara, & Luce-Kapler, 2000). A complicated system is a predictable sum of its parts; the behaviours within a complicated system are “planned, directed and determined by their architectures” (Davis et al., 2000, p. 55). Examples of learning theories that might envelop these concepts of a complicated system include both behaviourism and mentalism (Davis et al., 2000). Within these theories, “behaviour and cognition are mechanical process – and, hence, law-abiding” (Davis et al., 2000, p. 62). Complicated systems are not the same as complex systems.

Complex systems exceed the sum of their components. They are more “spontaneous, unpredictable and volatile – that is, *alive* – than complicated systems” (Davis et al., 2000, p. 55). They are self-organizing, self-maintaining, dynamic and adaptive. Complex learning theorists regard learning as participation in the world: a co-evolution of knower and known that transforms both (Davis et al., 2000). With constructivism, identified as a complex learning theory, “(l)earning is no longer seen as a process of “taking things in” but of adapting one’s actions to ever-changing circumstances. Here, ‘action’ refers to more than observable behaviors and includes brain activity, perceptions, and other dynamic processes (Davis et al., 2000).

Seymour Papert, with constructionist theory, built on the ideas of Piaget. Blikstein (2013) stated, “(i)f a historian were to draw a line connecting Jean Piaget’s work on developmental psychology to today's trends in educational technology, the line would simply be labeled 'Papert.'" (para 1). Papert's ideas of knowledge construction drew heavily on Piaget's theory of knowledge development and how children understand the world differently than adults; children are not simply mini-adults nor are they empty vessels to be filled (Kafai, 2006). As Papert and Harel (1993) explained,

> Constructionism shares constructivism's connotation of 'learning as building knowledge structures' irrespective of the circumstances of the learning. It then adds the idea that this happens especially felicitously in a context where the learner is engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe. (p. 1)

Constructionism builds on the mechanisms of assimilation and accommodation; it further focuses on the processes that help learners make connections with what they already know (Kafai, 2006). Moving beyond Piaget's work, constructionism theory included appropriation – how learners make knowledge their own and begin to identify with it (Kafai, 2006). These appropriations can include both intellectual and emotional values.

Physical objects, belonging to Popper's World 1, include objects to think with such as programs, robots, or games, play a key role in knowledge construction. Where Piaget saw formal abstraction as the ultimate goal, constructionists value equally the concrete and the abstract (Kafai, 2006). Papert (1993) emphasized the importance of learning cultures and suggests that learning might best be facilitated by improving the connectivity in the learning environment by actions on cultures rather than on individuals.

While knowledge building is rooted in constructivism, it is notably different

(Scardamalia, 2002). “Because of the slipperiness of words, the difference is difficult to convey, although teachers are very much aware of the difference once they have made the transition” (Scardamalia, 2002, p. 74). Two key characteristics have been identified in order to help better understand the differences between constructivism and knowledge building: intentionality and community knowledge (Jacobsen, 2010).

Intentionality and community knowledge. Intentionality is a defining characteristic of knowledge building and separates knowledge building from constructivism. By intentionality, Scardamalia and Bereiter (2010) explained that knowledge building is very purposeful in seeking to advance the current body of knowledge through the continual improvement of ideas. In contrast, learning within a constructivist approach, while it can be purposeful, can also be described as unconscious or even incidental. Intentionality involves higher levels of agency whereby students take responsibility for meeting objectives, and managing acquisition of knowledge and competencies (Scardamalia & Bereiter, 1991).

Intentionality further involves designing for classroom communication patterns and practices that facilitate knowledge building (Scardamalia & Bereiter, 2010). Oftentimes the patterns and practices in place in a classroom can impede the process of knowledge building (Scardamalia, 2010). A well-known example of this type of discourse is a dialogue sequence referred to as Initiate-Response-Evaluate (IRE) in which the teacher asks a question to which the answer is known, the student responds and the teacher evaluates the response as right or wrong (Enyedy & Stevens, 2014). In and of itself, it is neither good nor bad as an approach to discourse; rather, its merits or demerits depend on the purpose it is meant to serve. However, it may lead students to believing that learning is a quick recall of factual information (Enyedy & Stevens, 2014).

Alongside intentionality, Jacobsen (2010) identified community knowledge as a characteristic that further differentiates knowledge building from constructivism. While learning is a personal matter, knowledge building is done for the benefit of the community and is focused on the creation and improvement of knowledge of value to one's community (Jacobsen, 2010). In order to create and maintain a community devoted to ideas and to idea improvement, a supportive learning environment, along with teacher effort and artistry, is required (Jacobsen, 2010).

Regarding community knowledge, Stahl (2004) explained, "(i)t is hard for most people to imagine how a group can have knowledge, because we assume that knowledge is a substance that only minds can acquire or possess, and that only physically distinct individuals can have minds (somewhere in their physical heads)" (p. 82). Davis at al. (2015) developed a notion of community as collective cognition; a community is understood *as a learner* – not a collection of situated learners but a situated collective learner. The community has its own coherence and its own evolving identity and is part of a similarly coherent and evolving situation (Davis et al., 2015). Underpinning this construct of community knowledge is the theoretical framework of distributed cognition.

Distributed cognition. Informed by cognitive psychology, anthropology and sociology (Cole & Engeström, 1993), distributed cognition proposes a way of thinking about cognition not as being confined to an individual but rather as distributed across both internal and external structures: the human brain and body, communication among individuals, interactions with others, and artifacts in external social and physical environments (Parchoma, 2015). These internal and external structures constitute an activity system that is constantly shifting dynamics, where equilibrium is the exception and tensions, disturbances and innovations are “the engine of change” (Cole & Engeström, 1993, p. 8). In other words, distributed cognition theorists propose that learning is not limited to the individual but rather can also be distributed across objects, individuals, artifacts and tools in the environment or the activity system.

A central characteristic of the activity system is the mediation of relations through artifacts (Cole & Engeström, 1993). An artifact, as defined by Stahl (2002), is a meaningful object created by people for specific uses. Mediation provides a medium or middle ground through which individuals in the activity system can interact with ideas (Stahl, 2002). The artifacts, or tools for mediation, can be both material and symbolic and among which, language is the master tool (Cole & Engeström, 1993).

In their discussion of distributed cognition, Zhang and Patel (2006) focused on the internal and external representations of the cognitive system. Internal representations can include the knowledge and structures in the individual mind whereas external representations can include knowledge and structures in the external environment, including, but not limited to, cognitive artifacts such as shapes and positions of symbols, spatial relations, memory aids to reduce memory load, maps, written texts, graphs, tables, diagrams, webs (Klein & Leacock, 2012; Zhang & Patel, 2006). Distributed cognition, in this sense, refers to the “distribution of information and knowledge between and across internal and external representations” (Zhang & Patel, 2006, p. 138). These distributions, enacted across a group of individuals, “can produce emergent group properties that cannot be reduced to the properties of the individual” (Zhang & Patel, 2006, p. 139). Zhang and Patel’s ideas (2006) converged with Cole and Engeström (1993) ideas in suggesting the importance of multivoicedness within distributed cognition as a way to combine viewpoints, crosscheck and reference and provide an overall richness of resources. This multivoicedness allows group members to work together in a more advanced zone of proximal development or "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers" (Vygotsky, 1978, p. 86). It is through the theory of distributed cognition that the characteristics of community knowledge begin to take shape.

Critique of Knowledge Building. In looking across the literature, certain critiques of knowledge building come to light. By framing knowledge building in Popper's three-world epistemology, Bereiter (2002b) disentangled mind from knowledge; Talkhabi and Karrazi (2011) argued, "no modern philosopher of mind or epistemologist explicitly denies the relationship between knowledge, mind and education" (p. 1003). However, while Bereiter (2002a) did state the need to disentangle the mind from knowledge, he also went on to state, "obviously mind and knowledge are related" (n.p.) but that disentangling these helps to conceive of the mind as something other than a container and knowledge as the stuff in people's heads.

Talkhabi and Karrazi (2011) posited that recognizing the distinction between knowledge related to World 2 and knowledge related World 3 would be difficult, as no distinctive boundary between those worlds exists (Davari-Ardakani, 2000). Bereiter (2002a) concurs that it is difficult to distinguish boundaries but questions whether this difficulty in establishing a distinct boundary is serious enough to discourage us from the efforts of knowledge building.

Further criticism of Bereiter (2002b) is in response to his suggestion that creating knowledge is the goal of education. Talkhabi and Karrazi (2011) stated,

> it is true that we live in an era of knowledge society, but can we say that the most important task of education is to internalize the cultural values of knowledge creation? …It seems that from an educational point of view, not all educational goals may be reduced to knowledge work. (p. 1004)

Talkhabi and Karrazi (2011) questioned the feasibility of all students producing and improving knowledge. Bereiter and Scardamalia (2010), however, stated that children can genuinely create new knowledge, provided the comparison is not to works of genius but to standards that prevail in ordinary research communities.

Talkhabi and Karrazi (2011) further questioned Bereiter (2002b) in stating that while he relied on cognitive science to develop a new metaphor to replace the 'mind as a container', he failed to specify how education could be informed by the field of cognitive science. From a practical perspective, Talkhabi and Karrazi (2011) suggested that the essential problem of Bereiter's work is that of extension of knowledge creation to all students, obviously without verifying its feasibility. They question how schools best organize in order that knowledge work necessarily lead to improvement or creation of knowledge.

Gilbert (2005) also critiqued Bereiter's knowledge building model, suggesting that, on its own, it is not enough to support the development of a public education system that meets the needs of a post-modern society. This is because, while it may build employability, it will not build social cohesion – "the sense of society or inclusion we need if we are not simply to export our talent" (Gilbert, 2005, p. 100). Gilbert (2005) argued that we must take knowledge society ideas into account and use them strategically, not only to provide the resources we need for economic growth, but to preserve education's links with social justice and social cohesion. Bereiter (2010), however, stated that education is a democratic act, and therefore, all human beings have the right to take part socially in knowledge building. An important feature of knowledge building, according to Bereiter and Scardamalia (2003b), in socializing students into a knowledge-creating culture is:

> to make them feel a part of humankind's long-term effort to understand their world and gain some control over their destiny. Knowledge would not be seen as something handed down to them from dead White males. Rather, they would look on those dead White males—and other intellectual forbears of different race and gender—as fellow workers whose work they are carrying forward. The Knowledge Society, as it is taking shape today, seems headed toward a very sharp separation between those who are in it and those who, whether they live a continent apart or on the same street, are on the outside looking in. A knowledge building environment should provide all students an opportunity to be on the inside looking out. (p. 65)

With an emphasis, among other principles, on democratizing knowledge, I would suggest that there is a link with social justice and social cohesion.

Istance (2016) argued that, if knowledge building is to take hold, then learning must not be considered a byproduct of knowledge building but rather that we must consider that knowledge building is about learning. Istance (2016) argued that stating that learning is a by-product is not helpful to the cause. For knowledge building to succeed politically, Istance (2016) suggested that he would do his utmost to show how knowledge building is about learning since educators are, indeed, in the business of learning.

In addressing these critiques, I acknowledge that I continue to build my own understanding of the concept of knowledge building. At this time, as the teacher-researcher new to knowledge building, would suggest the following. Talkhabi and Karrazi (2011) question how schools best organize in order that knowledge work necessarily lead to improvement or creation of knowledge. I, too, question how I might organize and that question is central to this action research project. However, I enter into this research with optimism regarding the feasibility of knowledge building, in believing it is achievable.

I further recognize the merits in Talkhabi and Karrazi (2011) arguments that knowledge work is not the only goal of education. In reading across the literature, it is clear that there are many answers to the question of the goal of education, from learning as a central purpose (CBE, 2017b) to building social cohesion and social justice (Gilbert, 2005) to developing an engaged, entrepreneurial, and ethical citizen (Alberta Education, 2009) to name but a few. I would concur with Talkhabi and Karrazi (2011) in that knowledge building is not the only goal of education but I do believe that it is an important goal and one that might even lead to the achievement of the other goals noted above.

I further concur with Istance (2016) in that, if we are to move forward with knowledge building in schools, we must emphasize that knowledge building is about learning. Currently, in a school board that emphasizes learning as its central purpose (CBE, 2017b), to be successful with knowledge building will involve emphasizing not only how knowledge building differs from learning, according to Bereiter (2002b) but perhaps more importantly how the two are connected and that knowledge building will always result in learning (Bereiter, 2002).

Philip (2011) suggested that knowing what knowledge building should look like will enhance a teacher's ability to guide the process, to tell when things are going wrong, and provide clues as to what kind of action should be taken. The guiding principles of knowledge building are now discussed.

Knowledge Building Principles

Several principles identified by Scardamalia (2002) work together to further elucidate knowledge building: real ideas and authentic problems; idea diversity; improvable ideas; rise above; epistemic agency; community knowledge, collective responsibility; democratizing knowledge; symmetric knowledge advancement; pervasive knowledge building; constructive uses of authoritative sources; knowledge building discourse; embedded, concurrent and transformative assessment. Scardamalia (2004) explained the interconnectedness of the principles and suggests that implementing one leads to unlocking another. As the purpose of this literature review is to better understand what knowledge building is and the current work being done, each of these principles are explored in further detail.

Real ideas and authentic problems. Real ideas and authentic problems are those that the learners formulate themselves because they care deeply about them (Scardamalia, 2004). Engagement, or the "extent to which a learner is actively involved with content, where ‘active involvement’ suggests that the person acts to maintain or extend their contact in order to increase their knowledge of it” (Jåravelå & Renninger, 2014, p. 673) is less of a physiological construct and more about connections to learning (Jåravelå & Renninger, 2014) and may increase when students are asked to deal with problems of relevance. “When knowledge building fails, it is usually because of a failure to deal with problems that are authentic for students and that elicit real ideas from them. Instead of connecting to the larger world of knowledge creation, the tasks or problems are mere exercises and are perceived by the students as such” (Scardamalia & Bereiter, 2006, p. 113). Along with the importance of working with authentic and relevant questions, Schwarz et al. (2015) suggested that working with problems that are too difficult for the individual and require multiple voices is considered necessary for collaboration.

Idea diversity. Within the community, diversity of ideas - ideas that surround or contrast other ideas - creates an environment where knowledge can advance (Scardamalia, 2004). Ideas evolve into new ideas as students take risks with ideas and work through complexity rather than focusing on finding the right answer (Tarchi et al., 2013). Idea diversity can be a good introduction for newcomers to knowledge building (Tarchi et al., 2013). Siqin, van Aalst and Chu (2015) suggested the importance of the social context for idea diversity. Groups that are too small do not always make conceptual progress due to a lack of idea diversity; larger groups may cause individuals to experience cognitive overload (Siqin et al., 2015). Social context, which can be, at least partially designed (Goodyear & Dimitriadis, 2013), requires special attention in order to best facilitate idea diversity.

Improvable ideas. Ideas and theories, as conceptual artifacts, may be improved in terms of quality, coherence or utility. Bereiter (2016), in response to the question of ‘how do you know if an idea or theory is getting better?’ posited the following criteria:

- It explains more facts
- It excludes more false statements
- It connects to more other explanations
- It explains things in more detail
- Parts of the explanation interlock so that it becomes increasingly difficult to modify parts without altering the whole
- It is able to more clearly identify what it fails to explain
- It generates better predictions
- It explains how causal factors work, rather than only identifying and quantifying their effects

According to Scardamalia and Bereiter (2006), “generating ideas appears to come naturally to people, especially children, but sustained effort to improve ideas does not” (p. 100). Students need to become “socialized into the world of work with knowledge” (Bereiter, 2002, p. 220). Andriessen & Baker (2014) suggested that, when working with ideas as conceptual artifacts, it may be of value to help students identify where their personal epistemologies lie on a spectrum from absolutist epistemology to evaluative epistemology. In absolutist epistemology, “knowledge prevails in complete ignorance of alternative possibilities” (Andriessen & Baker, 2014, p. 444). At the opposite end of the spectrum, evaluative epistemology, “knowing is an ongoing, effortful process of evaluating possibilities, one that is never completed” (Andriessen & Baker, 2014, p. 444).

Many of the traditional classroom experiences (those connected to knowledge sharing) could very well lead to an absolutist epistemology; a purposeful shift in classroom practices that sponsor an evaluative epistemology, such as those that engage students in collaborative argumentation involving knowledge elaboration, reasoning and reflection (Andriessen & Baker, 2014). In addition, when working toward idea improvement, students must feel a sense of psychological safety in order to take risks, reveal ignorances, and give and receive criticism (Bielaczyc & Ow, 2014; Scardamalia, 2004).

Rise above. Rise above entails working toward more inclusive principles and higher-level formulations of problems. It means learning to work with diversity, complexity and messiness, and, out of that, achieve new syntheses. To rise above is to push beyond oversimplifications and move beyond current best practices (Scardamalia, 2004). Stahl (2005) argued, “groups can construct knowledge in ways that significantly exceed the sum of the individual contributions and that the power of group learning can feed back into individual learning” (p. 88). Rising above entails summarization, synthesis and the creation of new concepts (van Aalst, 2009).

As students attempt to rise above, scaffolding can be of benefit (Bielaczyc & Ow, 2014; Lee et al., 2006; Moss & Beatty, 2010; Scardamalia, 2002; Philip, 2011; Zhang, Scardamalia, Lamon, Messina & Reeve, 2006; Zhao & Chan, 2014). Scaffolds exist so that work can be shared between the learner and the more knowledgeable other or agent (Reiser & Tabak, 2014). Scaffolds allow for the completion of a task more complex than a learner may be able to handle on their own as well as learning from the experience of using the scaffold itself (Reiser & Tabak, 2014). Prompts are a form of scaffolding often used with students and aid students as they plan, monitor and execute analyses and investigations (Reiser & Tabak, 2014). These prompts may be verbal, written or embedded within technologies. It is expected that over a period of time, learners begin to regulate their actions as the tutor gradually reduces guidance, resulting in *fading* of scaffolding (Reseier & Tabak, 2014).

Epistemic agency. Epistemic agency is another principle of knowledge building. Here, the agency is directed toward working with the ongoing state of the episteme – the current body of knowledge. It refers to the amount of individual or collective control people have over the whole range of components of knowledge building—goals, strategies, resources and evaluation of results (Scardamalia & Bereiter, 2006). Scardamalia (2004) explained that students with a sense of epistemic agency set forth their ideas and negotiate a fit between personal ideas and ideas of others. They use contrasts to spark and sustain knowledge advancement rather than depend on others to chart that course for them. The responsibility for the success of the group is shared by all members of the group, rather than resting in the hands of a designated leader (Scardamalia, 2004).

Moss and Beatty (2010) suggested that there is no straightforward way to identify epistemic agency. However, in their work, they propose that the extent to which students use scaffolds, particularity the use of prompts, can be taken as evidence of epistemic agency. (Scaffolds are significant to knowledge work and are discussed in depth further on in this literature review.)

Community knowledge, collective responsibility. Students' contribution to improving their collective knowledge in the classroom is the primary purpose of the Knowledge Building classroom (Scardamalia, 2002). With collective responsibility, the success of the group is shared by all members of the group rather than resting in the hands of a designated leader (Erkunt, 2010; Scardamalia, 2004). However, this collective responsibility can often lead to cooperative groups where tasks are shared in such a way that one person is unable to speak to the work of another. Specifically taking responsibilities for understanding what is known and what needs to be known is referred to as collective cognitive responsibility (Scardamalia, 2004). Moreover, collective cognitive responsibility involves taking responsibility for insuring that others know what needs to be known, which is harder to maintain than responsibility for tangible outcomes (Scardamalia, 2004).

When investigating the possible social designs that lead to collective cognitive responsibility, Zhang et al. (2009) identified opportunistic groups, where, as opposed to fixed groups, members can move from group to group as needed, potentially resulting in deeper levels of inquiry and student gain. However, enculturation into the work of knowledge building becomes important as opportunistic groups can also result in some members experiencing feelings of disconnect from the group, interactions based on limited social configurations or fewer opportunities for metacognitive reflection (Siqin, et al., 2015).

Democratizing knowledge. The principle of democratizing knowledge acknowledges that all participants are legitimate contributors to the shared goals of the community; all can take pride in knowledge advances achieved by the group. The diversity within the group does not lead to separations along knowledge have/have-not. Ideally, everyone feels empowered to engage in knowledge innovation (Scardamalia, 2004). However, Ferreday and Hodgson (2008) questioned this utopian ideal of participation and, while concurring that collaboration and participation in learning is pedagogically effective, it comes, however, with the potential dangers or problems. “Participative processes can be experienced as tyrannical when participation is demanded by course designs, tutors and ultimately by participants in an unreflective and normative way” (Ferreday & Hodgson, 2008, p. 647). This tyranny, as noted by Ferreday and Hodgson (2008) can take the following forms: tyranny of decision making whereby existing decision making methods are overridden; tyranny of the group, where the group dynamic leads to decisions that reinforce the interests of the powerful; and tyranny of method, where participatory methods can be at the expense of other potentially also productive methods. Ferreday and Hodgson (2008) suggested the importance of reflexivity in collaborative group processes and the consideration of different ways and approaches to participation in order to avoid the potential for the tyranny or ‘dark side’ of collaboration.

Bielaczyc (2006) suggested that building this culture takes time, especially as students may have had different experiences in school and hold different beliefs about what is meant to happen in a classroom. Classroom teachers identified that it may take up to a year or more to impact culture in such a way that students can engage in knowledge building if they are not familiar with the principles (Bielaczyc, 2006). Working to build this culture may involve having the students and teacher work together to define and redefine the learning community as an ongoing process. As well, making exemplars of knowledge building available to everyone involved and providing opportunities to reflect on these exemplars may help to reify knowledge building (Bielaczyc, 2006).

Moss and Beatty (2010) proposed that democratization of knowledge may be achieved through the absence of the teacher's voice, in the sense that students themselves need to work to provide explanations and refrain from looking to the teacher to provide 'the answer.' In their work, Moss and Beatty (2010) concluded that democratization implies more than the legitimization of individual ideas, but an understanding that knowledge building requires multiple voices and perspectives, even early, not-very-well-worked-out-perspectives, in order to break new ground and continuously produce new knowledge to extend current understanding.

Symmetric knowledge advancement. Symmetric knowledge advancement refers to the idea that expertise is distributed within and between communities. Symmetry in knowledge advancement results from knowledge exchange and from the belief that to give knowledge is to get knowledge (Scardamalia, 2004). Students generate and continually work with promising ideas and synthesize multiple perspectives (Schwarz, de Groot, Mavrikis, & Dragon, 2015). This may also include identifying weaknesses, pursing better explanations and defining new problems (Zhang, Scardamalia, Lamon, Messina, & Reeve, 2007).

Community, in this sense, may be in reference to either the local community or society at large. To clarify, "it is unrealistic to expect every local community to make novel contributions to society's knowledge; what is important is that local discourse leads to understandings that are new to the local participants or superior to their previous understanding" (Zhang et. al, 2007, p. 121). Much of the literature reviewed demonstrates this point as knowledge contributions within local communities are much more common than knowledge contributions to the larger society.

Pervasive knowledge building. Pervasive knowledge building is not confined to particular occasions or subjects but pervades mental life—in and out of school (Scardamalia, 2004). Tarchi et al. (2013) discussed the presence of pervasive knowledge building in a classroom of senior kindergarten students and highlight the importance of connecting rather than compartmentalizing the curriculum. Further, pervasive knowledge building was evidenced in this example in students' willingness to join together the conversations had at school with those had at home in a joint problem solving space (Tarchi et al., 2013). At this time, the search for literature revealed few results specifically related to designs for pervasive knowledge building. However, technology, to be discussed more in depth at a later time in this review, has been identified as a support in the pervasive knowledge building process as it can act as a joint problem solving space that has the potential to be accessed both in and out of school.

Constructive uses of authoritative sources. Constructive uses of authoritative sources involve patterns and practices of communication where learners respect, understand critically, and examine authoritative sources of information, including textbooks, experts or the teacher. Traditionally, these sources often serve as ''end knowledge''—the ultimate state of understanding—and can, as a result, hinder continual idea improvement (Scardamalia, 2002).

Scardamalia (2002) explained that, in regards to this principle, students find and critically evaluate source material, they assess writer credentials, and they use source material to refine ideas, but do not use them as ultimate authority. Further, students show respect for expertise, but also understand that they can question authoritative accounts by asking *'What do experts say?' or 'What makes you think this person is an expert?'*

Scardamalia, (2002).

Bereiter (2002b) suggested that conceptual tools, facts and ideas necessary for higher-level understanding are accessed mainly through reading; reading for the purpose of knowledge building necessitates reading for comprehension and a move away from skills based instruction that is disconnected from the work of meaningful comprehension.

Luke, Dooley and Woods (2011) acknowledged the importance of reading that engages individual and community knowledge. In their view, reading comprehension is situated socially and intellectually as well as an internal cognitive process (Luke et al. 2011).

> There is nothing in the literature that suggests that we cannot have an approach to literacy that includes direct and explicit instruction in coding and semantic resources—but that also engages with student knowledge and community culture, rich themes and content, and is intellectually challenging. (Luke et al., 2011, p. 15)

In regards to this literacy, Luke (2012) stated, “unless we engage with substantive knowledge with intellectual engagement, we are setting the table but not delivering any food” (n.p.). When asking students to engage in the critical use of authoritative sources, Luke et al. (2011) suggested that readers need to be code breakers, sense makers along with critical analysts of what they read.

Knowledge building discourse. Knowledge building discourse involves a shift in communication practices and patterns. Discourse must move from knowledge telling to knowledge transforming practices. The focus must move away from the teacher at the middle of all discourse to student-centered discourse (Scardamalia, 2004).

van Aalst (2009) suggested that there is a need for a clearer articulation of the types of discourse necessary for knowledge building and distinguishes three modes of discourse – knowledge sharing, knowledge construction and knowledge creation. These three forms of discourse, corresponding to different theoretical perspectives, should not be regarded as stages of development in community discourse as each mode of discourse will be used within a community at different times and for different purposes (van Aalst, 2009). van Aaslt (2009) provided a framework for examining the most consistently used discourses within a given community. Along with these three forms of discourse, the significance of argumentation in knowledge building will be discussed.

Knowledge sharing discourse. Defined by van Aalst (2009), knowledge sharing discourse ensues as information is transmitted and accumulated between individuals and corresponds to a transmission theory of communication. This theory of communication as transmission, as explained by Pea (1994), centers on the practice of transmitting messages over distance by way of oral messages, written messages or telecommunication in order to exert control. In a collaborative inquiry, knowledge sharing might involve the introduction of information and ideas without interpretation, evaluation or development (van Aalst, 2009). Knowledge sharing can be seen as an accomplishment, especially in competitive environments where people may not be inclined to share what they are doing unless it is seen as a way of enhancing social positions (van Aalst, 2009).

This concept can be likened to knowledge-telling (Scardamalia & Bereiter, 2010) whereby declarative knowledge is shared which can then lead to a more surface understanding or "knowledge *about*" (Scardamalia & Bereiter, 2006). The ideas shared are often not reflected upon, challenged or refined in a purposeful way and can be related to naïve realism, or a belief that data speaks for itself (van Aalst, 2009). It is this "knowledge *about*" that tends to dominate traditional educational practices with a focus on textbook usage, subject-matter tests (Scardamalia & Bereiter, 2010) and on curriculum as a body of knowledge to be transmitted (Smith, 2000). In sum, knowledge sharing is more closely aligned with conventional educational practices than with those practices necessary for the 'knowledge age'.

Knowledge construction discourse. Knowledge construction, considered within cognitive psychology, refers to the processes by which students solve problems and construct understanding of concepts, phenomena, and situations (van Aalst, 2009). The basic assumption here is that students make ideas meaningful by connecting to prior experiences as a way of understanding concepts or phenomena and asking fact seeking questions (van Aaslt, 2009). The cognitive processes are situated in that they are mediated by social interactions within a group and by the particular technologies with which they are working (van Aalst, 2009).

Knowledge construction can lead to deeper understanding of a problem identified as a focus (Cress, Stahl, Ludvigson, & Law, 2015), or indeed a restructuring of knowledge or the invention of new concepts (van Aalst, 2009). Knowledge construction may lead beyond declarative knowledge toward a deeper, more implicit or intuitive understanding referred to as "knowledge *of*" and yet is often neglected in traditional schooling (Scardamalia & Bereiter, 2006). van Aalst (2009) suggested that knowledge construction discourse encompasses information sharing, evidence of ideation, interpretation of information, synthesis, and planning and reflection. Knowledge construction involves a range of cognitive processes, including the use of explanation-seeking questions and problems, interpreting and evaluating new information, sharing, critiquing, and testing ideas at different levels, producing deeper knowledge in complex domains that knowledge sharing (van Aalst, 2009).

Knowledge creation discourse. The term “knowledge creation” is used in the literature on expertise and innovation in order to describe how companies, organizations, and academic fields develop the ideas needed to sustain innovation (van Aalst, 2009). Knowledge creation discourse involves seeking a deeper understanding beyond that which is already known (van Aalst, 2009). This form of discourse involves the design and improvement of conceptual artifacts such as theories, explanations, and proofs (Bereiter 2002).

It would, as with knowledge construction discourse, entail information sharing, evidence of ideation, interpretation of information, synthesis, and planning and reflection; however, it would move beyond this by involving a sense of community, explanation-seeking inquiry, interpreting and evaluating information, knowledge advancement, and insight into these processes (van Aalst, 2009). The community discourse moves beyond that of knowledge construction by way of meta-discourse that: identifies priorities and long-term goals, decides how to mentor newcomers, evaluates knowledge advances and makes arguments for the next stage of inquiry (van Aalst, 2009).

Argumentation discourse. Bereiter (2002b) argued “people are usually quite adept at finding the flaws in arguments they are opposed to; logic tends to desert us when it comes to recognizing the flaws in arguments we are disposed to believe, especially arguments of our own invention” (np). Scardamalia and Bereiter (2014) advocated that knowledge building can be achieved through a “make-it-happen” heuristic and that this is preferable to arguing. However, as people work together to share understandings, contradictions will arise. Contradictions are often considered negatively when they could be seen as the drivers of the collaborative process (Singh, Hawkins & Whymark, 2010). Contradictions can lead to argumentation, a process that may, indeed support students in knowledge elaboration, reasoning and reflection (Andriessen & Baker, 2014). Participating in argumentation also allows students the opportunity to come to understand the argumentative structures (Andriessen & Baker, 2014).

Argumentation is essential for building knowledge as it establishes a dialectical exchange where students prompt one another to produce claims and evidence and challenge each other with alternative perspectives (Felton, Garcia-Mila, Gilabert, 2009). Felton et al. (2009) defined argumentative discourse as discourse in which individuals elaborate, juxtapose and evaluate opposing viewpoints. In this discourse, individuals must recognize that they hold conflicting views and they must engage in dialogue to resolve that conflict (Felton et al. 2009). Felton, Garcia-Mila, Villarroel and Gilabert (2015) proposed that, in order to harness the power of argumentative discourse, it is important to differentiate between persuasion and deliberation dialogue. Persuasion dialogue "is an adversarial exchange in which speakers advance incompatible claims with the goal of convincing others to accept their claim" (Felton et al., 2015, p. 374). On the other hand, "deliberation dialogue is a collaborative exchange in which speakers hold incompatible claims and seek to resolve these differences to arrive at a consensual decision" (Felton et al., 2015, p. 374). However, it may be unrealistic for individuals engaged in dialogue to consistently reach consensus; this ideal may undermine diversity through persuasion.

Andriessen and Baker (2014) opposed critical discussion, in which participants begin with a difference of opinion, and have accommodation and understanding as a goal, with explanatory inquiry where the goal is to converge on a solution or conclusion. Students who understand that the goal of dialogue is to improve ideas should, therefore, be deliberative or explanatory, demonstrate sustained commitment to dialogue (Andriessen & Baker, 2014) and produce more complex, well-rounded arguments than peers who work toward persuasion (Felton et al., 2015). Overall, knowledge-building discourse involves recognizing that contradictions can support the knowledge building process if we can recognize how to engage with contradictions in productive ways.

Embedded, concurrent and transformative assessment. Embedded, concurrent and transformative assessment is used to identify problems as the work proceeds and is embedded in the work of the community each day. The community engages in its own internal assessment, which is both more fine-tuned and rigorous than external assessment, and serves to ensure that the community's work will exceed the expectations of external assessors (Scardamalia, 2004).

As an assessment practice, Lee, Chan and van Aalst (2006) explored the use of knowledge building portfolios for which students are asked to identify collective knowledge advances documenting the community's best work and progress. Students were provided with principles conceptually related to those of knowledge building and they were asked to assess their work. This design suggested that when students are provided with the related principles, they become more aware of what productive discourse entails; the principles are scaffolds for their knowledge building progressive inquiry. Knowledge building portfolios may also have potential to scaffold collective knowledge advances (Lee et al., 2006).

Resendes, Scardamalia, Bereiter, Chen and Halewood (2015) investigated the role of meta-discourse and group level feedback tools. These tools, which were visual in nature, included 1) word clouds which compared the students' use of discipline specific vocabulary to that of the experts in the discipline and 2) bar graphs which measured the use of the scaffolds (i.e. knowledge building discourse prompts) provided through the technology. It was concluded that these visuals supported students in productive meta-discourse whereby they recognized trouble spots in the knowledge building process and initiated changes to discursive practices by increasing the use of discipline specific vocabulary and scaffolds (Resendes et al., 2015).

In sum, to differentiate knowledge building from constructivism, two key characteristics were identified: intentionality and community knowledge. The principles which help to elucidate these characteristics - real ideas and authentic problems; idea diversity; improvable ideas; rise above; epistemic agency; community knowledge, collective responsibility; democratizing knowledge; symmetric knowledge advancement; pervasive knowledge building; constructive uses of authoritative sources; knowledge building discourse; embedded, concurrent and transformative assessment- were explored. Scardamalia (2004) acknowledged that knowledge-building principles are often considered to be more abstract and less procedural, which can be problematic for teachers trying to bring knowledge building to life with students in the elementary school classroom.

While technology is not mandatory in a knowledge building community, it can be a way to reify the principles (Scardamalia, 2002). What is the role of technology in knowledge building? How can technology be integrated with these principles? The remainder of this literature review will address these questions in the exploration of computer supported collaborative learning (CSCL) environments.

Knowledge Building and Computer Supported Collaborative Learning

The work of knowledge building, as described by the defining characteristics (intentionality and community knowledge) and related principles outlined above can be reified through the use of technology (Scardamalia, 2002). Bereiter and Scardamalia (2014) explained that although

> knowledge building can go on without technological assistance—and often does in adult knowledge work—technology can provide a number of supports that could be helpful in many work contexts but that have proved essential in enabling school students to carry through efforts at knowledge creation. Teachers who have tried to implement knowledge building without a supportive digital environment have simulated these environments with lower-tech devices such as sticky notes and pockets on a bulletin board. This demonstrates that, valuable as oral discussion may be in creative work with ideas, something beyond it is required in order to keep students' ideas alive as objects of inquiry. (p. 42)

Creating a shared intellectual resource and a rallying point for community work helps to replace tasks, lessons, and projects, replacing them with a system of interactions around ideas that leads to the continual improvement of these ideas (Scardamalia, 2004). One such approach to the use of technology is that of computer supported collaborative learning (CSCL). This section will seek to describe the key characteristics of CSCL, the theoretical underpinnings and current work in the field specifically connected to knowledge building.

Computer supported collaborative learning. Computer supported collaborative learning is a field of work that studies knowledge building, group and individual perspectives, mediation by artifacts and interaction analysis (Stahl, 2002). Either with learners at a distance or co-present, CSCL refers to situations in which computer technology plays a important role in shaping collaboration (Goodyear et al., 2013).

CSCL researchers seek to understand collaborative learning mediated by computers or networked devices (Stahl, Koschmann & Suthers, 2014) as learners interact with each other over time and space, or within the same physical space using computational devices to facilitate face-to-face communication (Stahl et al., 2014).

While previous work with instructional technology has focused on the mind of the individual with the understanding that learning is a psychological matter, CSCL researchers focus on group cognition and the processes of meaning making (Stahl, 2004). Meaning comes from the interaction of the individuals rather than individuals on their own (Stahl, 2004) as cognition may be distributed across learners, their teacher, community resources and technologies through interactions, discourses, and problem-solving activities (Parchoma, 2015). Cress, Stahl, Ludvigson and Law (2015) suggested that perhaps the most important aspect of CSCL is the detailed analysis of this distribution, the resulting interactions and the learning that takes place during collaborative activities. Detailed analysis will allow designers for learning to better understand the role of scaffolding, the use of material and symbolic tools, communication practices, the use of relevant resources and the group's developing understandings (Parchoma, 2015).

In a computer supported collaborative learning environment, technology has the potential to be used to in such a way to create a communal, multimedia knowledge base that can visually trace the community inquiry (Bielaczyc & Ow, 2014). The role of the computer shifts from an instructional tool used to provide facts and figures to that of a tool used to support collaboration by providing media, communication and scaffolding for production student interaction (Stahl et al., 2014). Networked technology supports sharing and feedback for idea improvement, thus “disrupt(ing) the flow of information in the classroom – students’ ideas, questions, criticism and suggestions (are) contributed to a public space that (is) equally accessible to all, rather than information flowing through the teacher” (Jacobsen, 2010, p. 2). In CSCL, a technical tool generally mediates the interactions among the group members (Cress et al., 2015).

CSCL can facilitate the process supporting students in collaborating and reflecting on their developing understandings (Sawyer, 2014). Technology can provide a digital space for externalizing, articulating and tracking the progress of the work of knowledge building. Bransford, Brown and Cocking (2000) explain that, by externalizing and articulating still-developing knowledge, students think more deeply and learn more rapidly. Externalization of developing ideas can provide a constant reference point and serve as a sort of memory for the group. It provides a common ground or meeting place for discussion (Lu, Bridges & Hmelo-Silver, 2014). Articulation allows for opportunities for reflection and meta-cognition (Sawyer, 2014).

In taking on the work of designing for learning in CSCL, Stahl et al. (2014) cautioned that it is important to consider that no form of technology, in and of itself, has the capacity to change practice. Rather,

> to create the possibility of an enhanced form of practice requires more multifaceted forms of design (bringing in expertise, theories and practices from various disciplines): design that addresses curriculum (pedagogical and didactic design), resources (information sciences, communication sciences), participation structures (interaction design), tools (design studies) and surrounding space (architecture). (p. 490)

Further, Stahl (2005) claimed that introducing technological aids for communication, computation and memory inevitably introduces new problems and changes social interactions, tasks and physical environment. The design for learning must carefully consider social composition of groups, the collaborative activities and the technological supports (Stahl, 2005).

Designing for learning in CSCL involves presenting complex problems and introducing the structures necessary to solve those problems (Parchoma, 2015). These structures, or epistemic games, play a key role in building community knowledge within a discipline (Zenios, 2010), and can be employed in order to improve ideas, explore the diversity of ideas and to work toward rise above (Bielaczyc & Ow, 2014). Goodyear & Zenios (2007) introduced epistemic games and epistemic fluency as a framework for connecting knowledge and behavior in an attempt to "pin down some of the slippery thinking about the capacity to engage in knowledge work" (p. 376). In playing epistemic games, students use epistemic forms - "structures which play a key role in guiding inquiry within a discipline, and examples of these include lists, hierarchies, and axiom systems" (Zenios, 2010, p. 261) – and make moves as part of a learning community that helps advance inquiry (Parchoma, 2015; Zenios, 2010). Forms are often introduced as scaffolds in the epistemic game that can be used to help organize and representing information in appropriate ways (Collins & Ferguson, 1993; Goodyear & Zenios, 2007). These forms must be taught, not as rote memory, but rather as students try to make sense of the phenomena being studied (Collins & Ferguson, 1993). This is especially relevant to the work in a CSCL environment as scaffolds are consistently used in a well-designed environment to support students as they move toward achieving learner outcomes (Verdú & Sanuy, 2013).

As students continue to engage with a variety of epistemic games, the expectation is that they will improve epistemic fluency in that they are actively and fully engaged in collaborative learning activities (Zenios, 2010). As students work toward achieving epistemic fluency, supports, or scaffolds, can be used. Moving forward, an exploration of the theoretical underpinnings will help to further understand the relevance of CSCL to the work of knowledge building.

Underlying theories of CSCL. The theories most relevant to CSCL are those theories that concern themselves with cognition and collaboration. Vygotsky (1978) is recognized as one of the main theoretical sources for CSCL as he claimed that group learning generally precedes individual learning and this group learning is connected to the zone of proximal development (Engeström, 2009; Goodyear et al. 2013; Stahl, 2004). This zone of proximal development (ZPD) is recognized as the difference between what the individual can achieve independently and what can be achieved with support (Stahl, 2011) and is meant to be used in such a way as to support learning (Vygotsky, 1978). The zone of proximal development can apply as well to collaborative group work as, cognitively, the group may have the ability to achieve more than the individual. Further, Vygotsky noted the importance of mediation or "how one stimulus could mediate the memory of, attention toward or word retrieval about another stimulus" (Stahl, 2011, p. 5). Vygotsky's initial idea of cultural mediation of actions (first generation activity theory) is commonly expressed as the triad of subject, object, and mediating artifact and represents the first generation of activity theory (Engeström, 2009). According to Engeström (2009)

> (t)he insertion of cultural artifacts into human actions was revolutionary in that the basic unit of analysis now overcame the split between the Cartesian individual and the untouchable societal structure. The individual could no longer be understood without his or her cultural means; and the society could no longer be understood without the agency of individuals who use and produce artifacts. (p. 54)

While Vygotsky emphasized the social nature of learning, his interest remained in the investigation of the efforts of the mediated collaboration on the individual cognition and focused on the individual as the unit of analysis. More recent theories that both critique and build on Vygotsky's (1978) ideas by considering cognition distributed across humans, tools, artifacts and environments, and cultural diversity, leading to second and third generation activity theories (Engeström, 2009) that shift the focus of analysis to social practices. In third generation activity theory, there are five principles:

- A collective, artifact-mediated and object-oriented activity system is taken as the prime unit of analysis
- A multivoicedness exists in a community of points of view, traditions and interests
- Activity systems take shape and transform over lengthy periods of time;

their problems and potentials can only be understood against their own history.

- Contradictions, or structural tensions within and between systems, play a central role as sources of change and development
- Expansive transformations are possible in the activity system when the object and motive of the activity are reconceptualized to embrace wider horizon of possibilities than in the previous mode of the activity. (Engeström, 2009)

While they are not CSCL theorists, Lave and Wenger's (1991) work regarding communities of practice and apprenticeship as a model for learning highlighted the relevance of situated learning for the field of CSCL (Stahl, 2011). Situated learning researchers claim that talking about knowledge that is decontextualized is unreasonable and that new knowledge and learning are located in communities of practice (Lave & Wenger, 1991), "Rather than asking what kind of cognitive processes and conceptual structures are involved (in learning), they ask what kinds of social engagements provide the proper context for learning to take place (Lave & Wenger, 1991, p. 14). Influenced by this relationship between learning and social situation, CSCL researchers emphasize the importance of allowing learners the opportunity to work in the way of the discipline as a form of apprenticeship (Stahl, 2011).

Also building on Vygotsky's (1978) theories, Engeström's third generation activity theory focuses on transformations in an activity system rather than on individual learning. It is based on a learning cycle with the following stages: questioning and critiquing accepted practices, analyzing, modeling new solutions, examining the new model, implementing, reflecting and finally consolidating (Paavola, Lipponen, Hakkarainen, 2002). In applying activity theory, the entire system -subject, mediator, object, division of labour, rules of social relations and the community productive forces- is considered the unit of analysis (Stahl, 2011).

Knowledge Building and CSCL in Practice

In looking toward examples of knowledge building and CSCL in practice, two key concepts include philosophies-in-practice and affordances.

Philosophies-in-Practice. Kanuka (2008) explained, “knowing our personal philosophy helps us to understand why we act and think the way we do about using e-learning technologies, as well as why others think and act the way they do about e-learning technologies” (p. 2). This literature review will briefly address philosophies in action.

Kanuka (2008) identified three philosophies: uses determinism, technological determinism and social determinism. Firstly, uses determinism emphasizes technological uses and focuses on the ways in which we use technologies within learning and teaching transactions. In this approach, technologies are perceived as neutral tools and are simply devices that extend our capacities. As users, we determine the effects of technological artifacts (Kanuka, 2008).

Social determinism perspective sees educators concerned with the integration of technological artifacts within social systems and cultural contexts. Educators holding this view are concerned about the ways that social and technological uses shape the form and content of the learning experiences (Kanuka, 2008).

Within the technological determinism orientation, technologies are viewed as causal agents determining our uses and having a pivotal role in social change. Educational technologists who hold this view may regard technology as a distracting and potentially even harmful component of education system (Kanuka, 2008). Alternatively, they may also hold the view that technology directly influences learning in a positive way (Kanuka, 2008).

Feenberg (2003) extended the discussion on philosophical perspectives in discussing technology along two axes: technology as autonomous versus humanly controlled, and technology as neutral versus value-laden. Regarding technology as autonomous versus humanly controlled, Feenburg (2003) elaborated and stated

> (t)o say that technology is autonomous is not of course to say that it makes itself. Human beings are still involved, but the question is, do they actually have the freedom to decide how technology will develop? Is the next step in the evolution of the technical system up to us? If the answer is "no" then technology can rightly said to be autonomous in the sense that invention and development have their own immanent laws which humans merely follow in acting in the technical domain. On the other hand, technology would be humanly controllable if we could determine the next step in its evolution in accordance with our intentions. (n.p.)

Along the second axis, technology as neutral, in that there is a complete separation of ends (goals) and means (tools) opposes technology as value-laden, in that the means (tools) form a way of life that includes ends (goals) (Feenberg, 2003). Once again, to elaborate,

> (f)rom (the neutral) perspective a technical device is simply a concatenation of causal mechanisms. No amount of scientific study will find in it anything like a purpose. But from another perspective this misses the point. After all, no scientific study will find in a 1000 yen note what makes it money. Not everything is a physical or chemical property of matter. Perhaps technologies, like bank notes, have a special way of containing value in themselves as social entities. (Feenburg, 2003, n.p.)

Determinists regard technology as autonomous and value neutral (Feenberg, 2003). Determinists, as previously discussed, contend that technology is not humanly controlled; technology controls humans, and shapes society to the requirements of efficiency and progress (Feenberg, 2003). Rather than adapt technology to our whims, we must adapt to technology (Feenberg, 2003). Instrumentalists view technology as controllable by humans but as value-neutral (Feenberg, 2003). Substantivists consider technology as value-laden and autonomous (Feenberg, 2003). Critical theorists view technology as value-laden and humanly-controlled (Feenberg, 2003). In considering each of these philosophies of technology, Feenburg (2003) suggested the importance of understanding, self-awareness and reflection on what we take for granted.

As a teacher-researcher moving forward with knowledge building in CSCL, I adopt the philosophical views of a critical theorist as a starting position. That is to say, I believe that there is a possibility for human agency as we make choices that influence how technology is developed. These choices will be made in regards to GAFE and how to design for knowledge building using GAFE. In this research, I contend that, as a teacher-researcher, I have a say in how technologies are adopted and practiced and how technologies might become a way of life in teaching and learning. Furthermore, I acknowledge, in keeping with a substantivist position, that technology is value-laden. With this, I further acknowledge that I am not simply adopting technology as a way of creating efficiency in the classroom. Rather, I am adopting the technology associated with this research in hopes of achieving a different way of life.

I acknowledge this position in the hope that it will help me to understand why I act and think the way I do about using e-learning technologies and with the intention of continual reflection on this philosophical stance, especially pertaining to technology as autonomous versus humanly controlled. By adopting this philosophy in this study, my specific choices concerning the use of the technology will be choices reflecting values rather than choices based on the efficiency of the tool (Feenberg, 2003).

Affordances. Connected to the concept of philosophies-in-practice is that of affordances. "Empirical studies involving technology, collaborative learning, and knowledge creation frequently invoke the concept of affordances" (Parchoma, 2014, p. 360). The term, although often used inconsistently (Parchoma, 2011; Parchoma, 2014), has been adopted into the field of CSCL as a framework for the design and evaluation of CSCL environments (Fu, Chu & Kang, 2013). Regarding affordances, Conole (2011) opined that using the term "provides a means of describing the relationship between technologies and users and, in particular, resultant actions" (p. 3) despite the ambiguity and confusion surrounding this term.

Looking back, Gibson (1977) first introduced the term affordances and defined it in terms of all action possibilities, hidden or not. Further, for him, affordances were measurable, independent of the ability of the agent to be able to recognize them and always in relation to and dependent on the capabilities of the agent. Norman (1988) introduced the term affordances to the field of Human-Computer Interactions (HCI). He opined that affordances are dependent on the agent's physical capabilities as well as the past experiences, goals, plans, values, and beliefs of that agent. More recently, Conole (2011) defined affordances as "inherent characteristics of different technologies [that] can be instantiated in different contexts, and through the different preferences of individuals and how they interact with technologies" (Conole, 2011, p. 1). Many have contributed to the discussion of affordances and in the following section, a small sampling of approaches to the analysis of affordances in CSCL are discussed.

In considering CSCL as an educational context that is collaborative, where the social context is the group, and in which the technological context is the computer-mediated setting (Kirschner et al., 2004), Kirschner et al. (2004) suggested that affordances should be analyzed in a way that reflects each of these contexts . As per Fu et al. (2013)

> (e)ducational affordance includes characteristics of the learning environment that facilitate collaborative learning behaviour; social affordance to characteristics that offer social-contextual facilitation in relation to students' social interaction; and technological affordance to characteristics that enable learners to accomplish learning tasks in an efficient and effective way. (p. 86)

In this, Kirschner et al. (2004) employed both the concepts of utility as per Gibson (1977), representing the functionality of that a system provides and usability as per Norman (1988), referring to how well the user can use the functionality to achieve a task (Fu et al., 2013).

Conole (2011) suggested a framework of positive and negative affordances in relation to the design of learning intervention. The positive affordances, as identified by Conole (2011) included collaboration, reflection, interaction, dialogue, creativity, organization, inquiry and authenticity. Negative affordances included time consuming (in terms of both development and support), difficult to use, costly, assessment issues, lack of interactivity and difficult to navigate (Conole, 2011). Conole (2011) suggested this list is more in keeping with Norman's (1988) concept of affordances as opposed to her earlier work which was more in keeping with Gibson's (1977) conceptual understanding.

Parchoma (2014) proposed that affordances are "neither abstract entities nor universal ICT properties. Technological affordances are descriptive of temporal relationships between human and technological actors within networked social environments" (p. 367). From this point of view, Parchoma (2014) suggested that actor network theory (ANT) "can provide a complementary set of conceptual resources with which to examine temporal relationships between human and technological actors in networked spaces" (p. 367) in that ANT can be used in the analysis of situations "in which it is difficult to separate humans and non-humans, and in which the actors have variable forms and competencies'' (Callon, 1998, p. 2).

In looking at affordances, Dohn (2009) suggested that

> (as) practices are dialectically bound to both tools and the attitudes and skills of agents, not "any old tool" will do, but neither will there be "the one and only tool" which ensures a given form of practice… the tool by itself, narrowly viewed, is relatively unimportant; it is the skill-relative affordance it poses for the agents in a

given context which matters. Or better, acknowledging that skills may develop, the skill-relative affordance it may come to pose in the given context is what matters. (p. 347)

The literature search revealed the following regarding affordances and various technologies used as supports in collaborative environments.

Current work in CSCL. One particular networked technology used in many knowledge building environments is Knowledge Forum®, designed specifically as a scaffold to support the collaborative construction of community knowledge (Scardamalia & Bereiter, 2010). Significant work has been done in the exploration Knowledge Forum® and how this scaffolding supports skill development. Specifically, this scaffolding includes a series of built in prompts that guide student discourse (e.g., I need to understand…, My theory…, New information…, A better theory…, Putting our knowledge together…). These scaffolds in Knowledge Forum® were used effectively in various contexts to support the process of knowledge building (Cacciamani, 2010; Moss & Beatty, 2010; Sun, Zhang, & Scardamalia, 2010; Zhao & Chan, 2014). Regarding the use of scaffolds, Reiser and Tabak (2014) discussed the importance of *fading* or the ability for the student to eventually have the skills and abilities necessary to do the work without the use of scaffolds, whether the scaffolds are used in or out of CSCL. The review of literature revealed a paucity of work around this concept of fading, both in CSCL generally and specifically when students used Knowledge Forum®.

Further, Knowledge Forum® provides a structure for linking ideas in a communal workspace. In these communal workspaces, students contribute notes that can then be referenced, modified or elaborated on by others in the group. This online tool allows for the tracking of the changing body of knowledge (Bielaczyc & Ow, 2014; Moss & Beatty, 2010; Phillip, 2011; Zhao & Chan, 2014). Making the effort to summarize the work in Knowledge Forum® also advances reflective discourse (van Aalst, 2009).

So, Seow and Looi (2009) suggested that limitations and challenge exist with Knowledge Forum®. The text-based functions may not support diverse learners or younger learners with limited linguistic abilities. They further suggest that Knowledge Forum® is often limited in terms of availability in school environments in terms of the number of computers or scheduling around the use of computers. This limited access may result in challenges related to pervasive knowledge building. Further to this, Resier and Tabak (2014) suggested that scaffolding should be individualized, providing just the right degree of support of fading at the right time and this can be challenging when using software with built in scaffolds such as Knowledge Forum®. An important question arising from this that will frame this study is whether technologies other than Knowledge Forum® can allow for the effective use of scaffolding and allow for individualization when necessary.

Newer networked technologies have been introduced in CSCL, including different Web 2.0 technologies. Dohn (2009) addressed the fact that tensions exist –both individual and institutional– when taking on the work of using Web 2.0 tools in the classroom. Web 2.0 is participatory in nature and this can create tension with both the individual and institutional beliefs that learning is acquisition. In order to better integrate Web 2.0 tools in CSCL environments, these tensions need to be alleviated by shifting individual and institutional beliefs (Dohn, 2009). Some examples of these Web 2.0 tools include wikis, Google maps, MetaFora and Google Applications for Education, each discussed in turn below.

Cress and Kimmerle (2008) explored the use of social software as a means to facilitate communication, interaction and collaboration in the form of a wiki. Wikis are a web-based application and do not require one to purchase or install software, are easily accessible and simple to use. Users work together to jointly create one hypertext, all the while adding, changing or deleting as deemed necessary. By investigating the social processes, the cognitive processes of the user and the mutual influences between the two, Cress and Kimmerle (2008) identified four forms of learning and knowledge building: internal assimilation (quantitative individual learning), internal accommodation (qualitative individual learning), external assimilation (quantitative knowledge building), and external accommodation (qualitative knowledge building)" (p. 113).

de Wever, Hämäläinen, Voet and Gielen (2014) also investigated the use of wikis and specifically questioned the use of collaborative scripts: a set of instructions to improve collaboration by structuring the interactive processes between learning partners, by organizing the task and the collaborative process. Students who were provided the scaffolding in the form of a script reported that they (1) read more of the pages in the wiki, (2) edited more of the pages in the wiki, (3) tackled the work more together, (4) felt themselves more responsible for the complete wiki, and that (5) were more inclined to feel the whole group was responsible for the wiki. Despite this, the authors concluded that while the use of scripts can benefit the collaborative process, there is no impact on the final product or content knowledge (de Wever et al., 2014). This conclusion was drawn using the individual as the unit of analysis, specifically pre- and post-tests of content knowledge and as a result, raises the question of whether the correct unit of analysis was used. It may be of interest to investigate the use of these scripts using the activity system as the unit of analysis, much like the work done in Knowledge Forum®.

So et al. (2009), using Google Maps, explored artifacts as a mediating tool for knowledge building and found that using multimedia functions, such as video/audio recording and digital cameras, students can easily create and modify digital artifacts captured in contexts. Combining the potential affordances of mobile and Web 2.0 technologies may support pervasive knowledge building (So et al., 2009).

In a project known as Learning to Learn Together, Schwartz, de Groot and Dragon (2015) explored the use of MetaFora and suggested that it offers a platform where students can work in a common space to plan, organize and solve problems in the areas of math and science. Further, Metafora system is comprised of (1) a visual tool for planning and reflecting on group work, (2) microworlds for experiencing phenomena and exploring problem spaces, (3) a space for argumentation, and (4) a module for observing group work and possibly intervening by sending messages. The system encourages students to come together with their findings and agree on solutions. Schwartz et al. (2015) suggested that collective reflection and peer assessment is afforded by this common space in MetaFora, allowing students to discuss past moves or plan future moves.

Overall, the studies listed above discuss how different technologies were used in ways to support collaborative processes among students. The technologies discussed above provide examples of how various technologies may provide a networked space for students to plan, share, collect, comment and provide feedback and to shift communication patterns in the classroom. The intention of this study is further explore potential technologies that might aid in the efforts of knowledge building.

Google Apps for Education (GAFE) is a suite of productivity applications that Google offers to schools and educational institutions for free. To work on documents and projects, students can access this suite of communication and collaboration applications from any device (EdTech Teacher, 2014). Along with the text based features, GAFE allows for the upload of videos and images. It includes tools for accessibility, including voice to text and mind mapping features. As a networked technology, GAFE affords teachers and students the same opportunity to “move beyond information sharing and surface uses of technology to embrace the intentional knowledge building practices, technology enabled environments and knowledge creating culture” (Jacobsen, 2010). At this time, there appears to be a paucity of research available that speaks to the effectiveness of GAFE being used in such a way, which warrants further investigation. While GAFE supplies the affordances to support knowledge building, it does not supply the pedagogical scaffolds. Google Applications for Education is the tool of interest for this research as it is the technology that is readily available for all users in the identified research context.

Social infrastructure framework. Bielaczyc (2006) argued that providing CSCL tools with diverse functionality is not sufficient to create effective learning environments for students. Social infrastructures, defined as the supporting social structures that enable the desired interaction between collaborators using the CSCL tool, must be carefully considered in order to gain a deeper understanding of how to create successful learning environments with technology-based tools (Bielaczyc, 2006).

Bielaczyc (2006, 2013) presented a framework for examining the social infrastructure referred to as the Social Infrastructure Framework and suggests that this framework can help in both designing and analyzing an implementation in CSCL by focusing on classroom social structures that impact the type of learning environment created with technology-based tools.

The Social Infrastructure Framework (Bielaczyc, 2006) included four interdependent dimensions: 1) the cultural beliefs dimension, 2) the practices dimension, 3) the socio-technico-spatial relations dimension, and 4) the interaction with the 'outside world' dimension. Bielaczyc (2006) explained that the cultural beliefs dimension is presented first as it provides a "substrate in which the remaining dimensions of the Social Infrastructure Framework operate…The cultural beliefs dimension influences and pervades the other dimensions but does not determine them" (p. 306). That is to say, the way that teachers and students conceptualize the cultural beliefs elements sets the stage for the classroom practices, the socio-techno-spatial organizations, and the ways that outsiders interact with the classroom. Conversely, the other dimensions can influence the types of cultural beliefs held by teachers and students (Bielaczyc, 2006). For each of these four dimensions, the corresponding sub-dimensions are as follows:

- the cultural beliefs dimension involves the mindset that shapes the way of life of the classroom and influences how a technology-based tool is perceived and used, including:
    - How is learning and knowledge are conceptualized
    - How students' social identity is understood
    - How a teacher's social identity is understood

    - How the purpose of the tool is viewed
- the practices dimension concerns the ways teachers and students engage, including:
    - the activities in which to engage students
    - the associated participant structures of students
    - the associated participant structures of teachers
    - coordination of on-tool and off-tool activities
- the socio-technico-spatial relations dimension focuses on how the organization of physical and cyberspace support student interaction with the technology-based tool, including:
    - student–teacher–machine–physical-space configurations,
    - student–teacher–cyberspace configurations
    - cyberspace–physical-space relations.
- the interaction with the 'outside world' dimension refers to the ways in which students interact, online and offline, with people outside of their immediate classroom context, including:
    - bringing in knowledge from the outside
    - extending the audience for student work
    - interacting with others. (Bielaczyc, 2006; 2013)

The Social Infrastructure Framework can be used in the evaluation of a classroom implementation of a technology-based tool (Bielaczyc, 2006, 2013). In considering how this framework might best support the work of designing for knowledge building, the following summary presents possible connections between the two frameworks.

Table 1

Summary of the Social Infrastructure Framework (Bielaczyc, 2006) and Possible Related Knowledge Building Principles (Scardamalia, 2002)

Dimension	Sub-dimension	Possible related knowledge building principle
Cultural beliefs dimension	Conceptualization of learning and knowledge	Improvable idea Idea diversity Rise above Pervasive knowledge building
	Understandings of students' social identities	Community knowledge, collective responsibility Epistemic agency Symmetric knowledge advancement Democratizing knowledge Rise above
	Understandings of teacher's social identity	Real ideas, authentic Problems Epistemic agency Constructive uses of authoritative sources
	Perceived purpose of the tool	Knowledge building discourse Concurrent, embedded, and transformative assessment
Practices dimension	Activities students are engaged in	Epistemic agency Real ideas, authentic problems Concurrent, embedded, and transformative assessment
	Associated participant structures of students	Community knowledge, collective Responsibility Knowledge building discourse Symmetric knowledge advancement Democratizing knowledge

	Associated participant structures of teachers	Community knowledge, collective responsibility Epistemic agency Symmetric knowledge advancement Democratizing knowledge
	Coordination of on-tool and off-tool activities	Knowledge building discourse Improvable ideas Idea diversity Rise above Pervasive knowledge building Concurrent, embedded, and transformative assessment
Socio-technico-spatial relations dimension	Student–teacher–machine–physical-space configurations	Epistemic agency
	Student–teacher–cyberspace configurations	Community knowledge, collective responsibility
	Cyberspace–physical-space relations.	Pervasive knowledge building Community knowledge, collective responsibility
Interaction with the ‘outside world’ dimension	Bringing in knowledge from the outside	Constructive use of authoritative sources Idea diversity Rise above
	Extending the audience for student work	Constructive use of authoritative sources Community knowledge, collective responsibility Idea diversity
	Interacting with others	Community knowledge, collective responsibility Pervasive knowledge building

	Idea diversity Rise above

Further to this comparative analysis, Bielaczyc (2006; 2013) used the Social Infrastructures Framework in the analysis of knowledge building. This framework was used Bielaczyc (2006; 2013) to better understand the classroom social structures that impacted the type of learning environment created with technology-based tools.

The final section of this literature seeks to uncover connections between current design thinking initiatives in education and knowledge building as defined by Scardamalia and Bereiter (2006).

Design Thinking and Knowledge Building

In this exploration of the principles of knowledge building and review of current approaches to education in the knowledge age, several connections between knowledge building and design thinking have become apparent and worthy of further exploration. For example, I wondered if, in designing for knowledge building in the classroom, could design thinking mindsets and protocols offer possible points of action? In this section, I review the literature on design and design thinking as a bridge to knowledge building.

Design and design thinking. Many researchers argue that fostering design thinking among today's learners is necessary for success in the knowledge age (Kelly, 2016; Koh, Chai, Wong, & Hong, 2015; Scheer, Noweski & Meinal, 2012). The Calgary Board of Education (2016) identified design thinking as one way of working toward a vision of personalization as learning that is built upon a comprehensive understanding of each child. This work has further involved understanding how design-thinking methodology might empower teachers to consider themselves designers of learning so as to design work worthy of students' time and attention (Friesen, 2009).

Design, when viewed as "a way of thinking that becomes habitual and not something to be turned on only for certain purposes…is especially appropriate for knowledge building in schools" (Bereiter & Scardamalia, 2014, p. 39). This section seeks to clarify what design and design thinking entail, and how design thinking may connect to the work of knowledge building.

Design and design thinking are integral to the production of things or artifacts: "design thinking is implicated in all aspects of the man-made world from physical artifacts to symbolic and conceptual objects like languages and mathematical theorems" (Koh et al. 2015, p. 3). Design thinking, in its "simplest terms, means taking the kind of thinking that goes on in design labs and applying it to the full range of problems that require thought" (Bereiter & Scardamalia, 2014, p. 39). Brown and Wyatt (2010) explained the design thinking process as a system of overlapping spaces: inspiration, ideation, and implementation.

> Think of *inspiration* as the problem or opportunity that motivates the search for solutions; *ideation* as the process of generating, developing, and testing ideas; and *implementation* as the path that leads from the project stage into people's lives. The reason to call these spaces, rather than steps, is that they are not always undertaken sequentially. Projects may loop back through inspiration, ideation, and implementation more than once as the team refines its ideas and explores new directions. Not surprisingly, design thinking can feel chaotic to those doing it for the first time. (Brown & Wyatt, 2010)

Whereas traditional epistemology takes the view of knowledge as verifiable truth, design epistemology is concerned with generating useful ideas to resolve existing real-world problems (Koh et al., 2015).

Kelly (2016) highlights design thinking as a creative, collaborative way to transform education from a consumptive practice to a creative one. Foundational to a thriving creative, collaborative culture in an educational context are key principles: the principle of infinite potential, the principle of interrelatedness and the principle of perceptual change. The principle of infinite potentials refers to a belief that any idea has new potential to grow into an infinite number of combinations of new ideas; human beings have the potential to produce an infinite number of ideas through the engagement in a creative, collaborative community (Kelly, 2016).

The principle of interrelatedness is the perspective that everything in the world - organic and inorganic - is in some way connected. Being able to see these relationships is essential in creative collaborative groups. Specifically, participants must seek to see and feel things through the eyes of others, manage the impact of their thoughts and emotions on others while understanding the thoughts and emotions of others (Kelly, 2016). In essence, Kelly (2016) argues that this ability to develop empathy is at the core of the creative, collaborative culture.

The third principle, the principle of perpetual change is the belief that educational design should enable participants to adapt to perpetual change as well as to create positive change through original research, production and action. Adapting to perpetual change is required to move creative, collaborative groups forward; a desire for predictability and stability will stifle the processes within the group (Kelly, 2016).

Alongside these principles, Kelly (2016) highlights eight developmental strands that support the growth of creative capacity, defined as “the level of complexity at which one can engage in creative practice at a point in time” (p. 9). These strands include:

- Collaborative development – all ideas are valued and all participants can engage in innovation and invention
- Research/ investigative development – set problems, ask questions, develop investigative dispositions
- Self-instigative development - greater learner autonomy, behaving with a sense of volition and choice, sustained motivation
- Generative development – the capacity to create alternatives for creative production, idea generation, ‘fuel for creativity’
- Experimentational development- testing and refining ideas
- Discipline complexity development – understanding of the disciple area/ field of study knowledge, content, processes and techniques
- Critical/ analytical thinking development – analysis and understanding of content and processes
- Creative sustain development – sustaining recurrent iterations of idea generation and experimentation. (Kelly, 2016)

Further consideration of these strands is given below to better understand how these developmental strands are conceptually connected with knowledge building.

Bridging knowledge building and design thinking. In looking side by side at both the knowledge building principles (Scardamalia, 2002) and design thinking as defined by Kelly (2016), there are similarities, conceptually speaking, between the two approaches to pedagogy. A summary of these possible connections is presented in Table 2.

Table 2

Conceptual Similarities Between Knowledge Building Principles and Design Thinking Principles & Developmental Strands

Knowledge Building	Creative Development and Foundational Principles for Design Thinking
Real ideas and authentic problems	Research/ investigative development; generative and experimentational development
Improvable ideas	Infinite potential, generative and experimentational development
Idea diversity	Infinite potential; generative and experimentational development
Rise above	Infinite potential; collaborative development; experimentational development
Epistemic agency	Self-investigative development
Community knowledge, collective responsibility	Collaborative development; creative, sustained development
Democratizing knowledge	Collaborative development
Symmetric knowledge advancement	Collaborative development
Pervasive knowledge building	Research/ investigative development
Constructive uses of authoritative sources	Critical/ analytical thinking development
Knowledge building discourse	Collaborative development
Concurrent, embedded, and transformative assessment	Critical/ analytical thinking development

Overlap between knowledge building principles and the developmental stands for design thinking seem to exist. Further relationships that exist between knowledge building and design thinking. For instance, Koh et al. (2015) situated design thinking in the same three-world ontology that Bereiter and Scardamalia situate knowledge building. To recall, World 1 represents the physical world, Word 2 represents the mental world and World 3 represents conceptual artifacts (Bereiter, 2002). Koh et al. (2015) explained that design thinking requires a person to be familiar with the nature of the problem and to conduct research as well as to consult with experts, which is arguably characteristic of World 3. The observation stage is directed at World 1 objects or events. The point of view stage relates to the inter-subjective of the world of personal experiences that constitute World 2. When engaged in design thinking, students are developing the ability to traverse the three worlds in a seamless way, which Koh et al. (2015) argued is essential to thriving in the fast-changing knowledge age.

Scardamalia and Bereiter (2003) distinguished belief mode from design mode when working with ideas. The term "belief mode" is derived from the traditional definition of knowledge as 'true and justified belief' and is often equated with rote as opposed to or meaningful learning. However, "attaining 'true and justified belief' requires meaningful learning… the wisdom of the past, whatever its source, comes down to us in belief mode, and it is in that mode that we interpret, argue about, and evaluate it" (Scardamalia & Bereiter, 2003, p. 38). Design mode, on the other hand, includes a "broad range of activities concerned with knowledge production and improvement: theorizing, invention, design, identifying promising ideas, and searching for a better way—in short, all the kinds of activities that mark a knowledge-creating organization" (Scardamalia &

Bereiter, 2003, p. 39). Closely related to design mode is ‘Design Thinking,’ an approach to learning that has been gaining in popularity in the local school system.

According to Bereiter and Scardamalia (2006), to employ the design mode of thinking is to engage in asking questions such as the following: (1) what is this idea good for, (2) what does it do and fail to do, and (3) how can it be improved? While Koh et al. (2015) suggested that “Bereiter and Scardamalia are focused on the design mode of thinking as a means to foster knowledge-building communities, their approach is compatible with approaches pioneered by design thinkers to foster social innovation” (p. 5). However, “perhaps because of its distinctive focus on examining the refinement of conceptual artifacts (which are the theories built by students), literature discussing learning through or by design…has seldom cited Bereiter and/or Scardamalia’s work” (Koh et al., 2015, p. 53). Both design thinking and knowledge building are principled rather than programmed approaches to education. Further, these principles seem to be tightly aligned. This action research sought to better understand connections between design thinking and knowledge building.

Gaps in the Literature

The following gaps and opportunities for future research were identified in the research. First, although exemplars of the knowledge building in a CSCL environment exist, a better understanding is needed of how teachers can bring this approach to knowledge building to life in classrooms (Bielaczyc & Ow, 2014; Chan, 2011). Those investigations that do exist regarding how to bring the model to life seem to be more so from the researcher than the teacher perspective. van Aalst and Truong (2011) explain that most research has been conducted in contexts in which the teachers, and sometimes the students, have had several years of experience in using the knowledge building approach. However, there is little research into how much progress towards knowledge building is possible within a single school year by a teacher and students new to this approach.

Scardamalia and Bereiter (2010) suggested “there is a wide gap between recognizing the need to increase and democratize innovative capacity and knowing what to do about it” (p. 12). Further, Zhang et al. (2009) recommended, “an ongoing research goal is to further understand the role of the teacher in collectively evolving knowledge-building processes” (p. 38). The call to better understand the teacher’s role in sponsoring knowledge building is of key interest in the present study. What does the work of knowledge building entail for the student learners and for the teacher, both as learner and as designer of learning?

Increased research interest has surfaced regarding CSCL design for enhanced collective and individual learning in complex classroom settings, with emphasis on both processes and outcomes (Zhao & Chan, 2014). Further to this, Bielaczyc (2006) suggested that student belief and epistemology are critical factors that influence the work of knowledge building. It will be of interest to examine whether students, while working in intentionally designed, computer supported, collaborative knowledge-building environments, move towards more sophisticated beliefs about knowledge and knowing. Finally, Bielaczyc and Ow (2014) questioned how educators might develop supportive tools and practices that socialize students into working together as a knowledge-building community and how research can deepen our understanding of change processes.

Regarding the design thinking initiatives in education, Koh et al. (2015) suggested that knowledge building principles seem analogous to design thinking in highlighting processes of forming, relating and synthesizing ideas. However, “it has not been examined whether knowledge building has any bearing on design capacity. It is, however, conceptually plausible to posit that there are relationships between knowledge building and design thinking” (Koh et al., 2015, p. 70). This action research was undertaken with the goal of contributing to the body of knowledge in relation to these identified gaps.

Conceptual Framework

Miles, Huberman and Saldana (2014) explained the importance of the conceptual framework in highlighting the key factors to be studied in educational research and the presumed relationships between these key factors. It can be considered “a map of the territory being investigated” (Miles et al. 2014, p. 20). The conceptual framework in Figure 2.1 has been created based the key factors that emerged from the literature reviewed in this chapter.

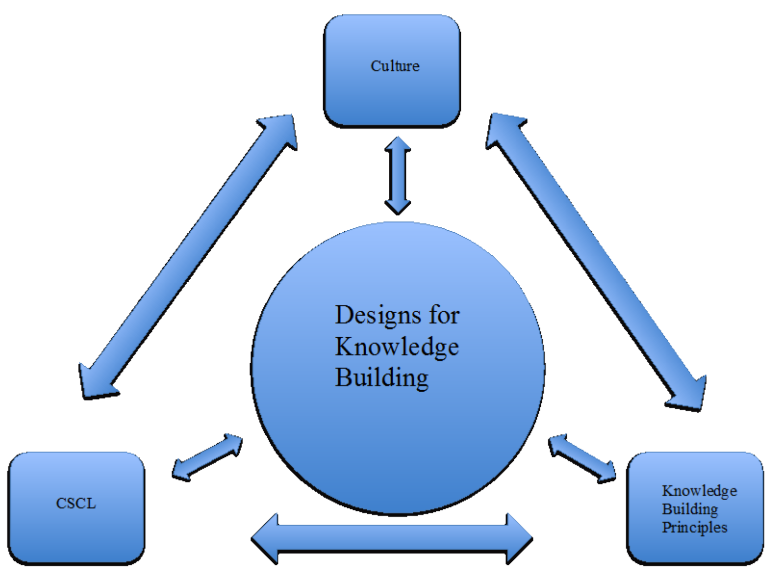


Figure 2.1: Conceptual Framework

Designing for knowledge building can be influenced by principled approaches to teaching including those principles identified by Scardamalia (2002), principled practical knowledge by Bereiter (2013) and design thinking principles. Scaffolds support students in the work of the CSCL community. All the while, cultural beliefs about knowledge and idea improvement in community are cultivated.

Summary

The purpose of this review was to engage in a dialogue with the literature to better understand what it might entail to move teaching practice and design towards a knowledge building approach to learning. It is a knowledge building approach that has been identified in the literature as one which might better engage students now participating in the ‘knowledge age’ of education (Bereiter, 2002). Specifically, this review explored knowledge building principles, distributed cognition within CSCL and design thinking initiatives in education and the connections to knowledge building. Gaps, resulting in opportunities for future research, exist in the literature and pertaining mainly to the teacher role and teacher perspective in the evolving process of knowledge building. Identified gaps are addressed by the remainder of this research in order to better inform me and more broadly, other practitioners, of how to design for and support knowledge building by elementary students in a CSCL environment. All concepts have been drawn together in the form of a conceptual framework. The third chapter offers a description of the methodological considerations as the research design plan.

Chapter 3

Methodology

This chapter begins by revisiting the purpose of the study as well as the research questions. Subsequently, a rationale is provided for the undertaking of both qualitative research and more specifically, practitioner action research. The chapter then provides a detailed examination of the context, the participants, the research design and the proposed analysis methods. In conclusion, ethical considerations, issues of trustworthiness, and limitations and delimitations of the research are discussed.

Purpose

The purpose of this practitioner action research study is to understand and design for a knowledge building community in an elementary school classroom, one that uses readily available technology to support the teaching and learning process.

Research Questions

Miles et al. (2014) explain that it is a "direct step from the conceptual framework to the research questions" (p. 25) in that the conceptual framework helps to decide which questions are important, what evidence needs to be gathered and how the research questions should be answered. Accordingly, the following qualitative research questions were originally noted in chapter one: What learning designs enable a class of students to engage in knowledge building? The study further involved understanding:

1. How do students engage with knowledge building principles?
2. How can scaffolds support participants- students and teacher- as they engage in knowledge building in computer supported collaborative learning using Google Applications for Education?

3. What literacy practices do participants engage in as knowledge builders?
4. In what ways can a knowledge-building model influence students' current epistemic cognition?

Over the course of the school year, however, the study evolved in its focus due to unforeseen complexity and diversity in the context, which is discussed in detail later in this chapter. The narrowed focus centered on understanding (a) how students engage with the knowledge building principles as defined by Scardamalia (2002); and (b) the quality of scaffolded discourse in computer supported collaborative environments.

However, the study also took on a new and additional focus as students engaged with the design thinking initiatives set forth by the local school jurisdiction. As my students and I began to engage in design thinking, the commonalities noted between the processes for design thinking and the knowledge building principles and scaffolds were noted; design thinking was noted as relevant to the work of knowledge building and, as the teacher-researcher, I decided that more consideration of these connections would be appropriate in the study.

This action research expanded to include understanding the ways in which a design thinking approach to education, as defined in chapter two of this work, might support or complement knowledge building for elementary students. In the literature review, design thinking is defined as a system of overlapping spaces: inspiration is the problem or opportunity that motivates the search for solutions; ideation is the process of generating, developing, and testing ideas; and implementation is the path that leads from the project stage into people's lives (Brown & Wyatt, 2010). This shift resulted in a new research focus: In what ways can does knowledge building support a design thinking approach to education? In sum, the research was bound by the following question: What learning designs enable a class of students to engage in knowledge building? The study further evolved to include a focus on understanding:

1. How do students to engage with knowledge building principles?
2. How can scaffolds support participants- students and teacher- as they engage in knowledge building in computer supported collaborative learning using Google Applications for Education?
3. What relationships exist between knowledge building and design thinking?

Rationale for Qualitative Research Design

Creswell (2015) explains that qualitative research approaches are concerned with exploring a problem and developing an understanding of a central phenomenon rather than looking for relationships among variables, as is the case with quantitative research approaches. Further, qualitative research "is concerned with how the complexities of the sociocultural world are experienced, interpreted and understood in a particular setting at a particular point in time" (Bloomberg & Volpe, 2012, p. 118) and is considered to be grounded in constructivist philosophy (Bloomberg & Volpe, 2012). This grounding in constructivism is in direct alignment with my own philosophical assumptions about learning in that "learning involves the active creation of mental structures, rather that the passive internalization of information acquired from others or from the environment (Nathan & Sawyer, 2014, p. 24-25). I would concur with Sawyer (2014) in that active participation in the construction of knowledge results in deeper understanding, more generalizable knowledge and greater motivation by learners.

With qualitative research, evidence is generally collected based on words or images and from a small number of individuals so that the views of those individuals can be obtained. The evidence collected is analyzed for themes to find the larger meanings, which leads to more depth, rather than breadth, of information (Creswell, 2015),

It is my contention, as a teacher-researcher, that this research was best served through a qualitative methodology as it sought to explore experiences rather than prove cause and effect by way of the manipulation of variables. Further, the research was undertaken in a complex, naturalistic setting, one that was emergent and evolving. The views and experiences of all research participants were essential to the work. There are many different genres of qualitative research and the following section provides a description and argument in favour of practitioner action research for this classroom based investigation.

Rationale for Action Research

Contemporary classrooms are complex systems and complex systems call for "holistic, contingent and exploratory approaches to inquiry" (Sumara & Davis, 2009, p. 359). Hinchey (2008) explains:

> This is a key area where action research is crucially different from traditional research efforts: the researchers are not outsiders… they are insiders, citizens of a school or other community, who explore improvements in areas they think important. And, the goals of the research are determined by the people who conduct it....Goals, as well as researchers, come from the inside rather than the outside. (p. 3)

As an insider, specifically a classroom based teacher, one who is setting goals and exploring improvement in learning, a practitioner action research approach was determined to be best suited this work. In order to better understand the origins and types of action research, a brief history of action research is presented.

History of action research. Action research has been around for some 80 years and has always been linked with social change for social justice (McNiff & Whitehead, 2011). Kurt Lewin is generally credited as having coined the term ‘action research’ (Carr, 2006; Carr & Kemmis, 1986; Hendricks, 2009; Mertler, 2009; Smith, 2001), asserting that people would be more motivated about their work if they were engaged in the action of decision-making (McNiff & Whitehead, 2011). Lewin, working with minorities and implementing various interventions, proposed the organizing structure of action research: an iterative cycle of observation, reflection, action, evaluation and modification. This structure remains influential today in all action research (Kemmis et al., 2014; McNiff & Whitehead, 2011). Burnes (2004) explained, in detail, how many have critiqued Lewin’s work for being too simplistic and mechanistic to accomplish open-ended change, for ignoring power and politics and for advocating for top-down management. However, these critiques, it is argued, have been based on narrow interpretations of Lewin’s work, or a failure to look at his work as a whole and, with this recognition, a renewed interest in Lewin’s work emerged (Burnes, 2004).

Action research was taken up in education in the early 1950’s, marking a departure from the dominant approaches to educational research, where teachers studied psychology, sociology, history and philosophy of education to where teachers were viewed as competent professionals who should be studying and in charge of their own practice (McNiff & Whithead, 2011). Stephen Corey, with his 1953 book, *Action Research to Improve Schools*, is credited with promoting action research in education; his work is particularly known for "having promoted and advanced the professionalism and status of teachers" (Hinchey, 2008, p. 12). However, toward the end of the decade, action research saw a decline in popularity, especially in the USA, where the launch of Sputnik motivated a return to focus on technical excellence by way of a Research, Development and Diffusion model, separating research and practice (McNiff, 2013).

The 1970's saw a resurgence of research ideas that coincided with and built on those of Lewin, resulting in a move toward participatory action research (Carr, 2006; Fals Borda, 2007). Where Lewin continued to consider the researcher as an outsider (Kemmis et al., 2013), proponents of participatory action research believe that "insiders have special advantages when it comes to doing research in their own sites and to investigating practices that hold their work and lives together in those sites—the practices that are enmeshed with those sites" (Kemmis et al., 2014).

Fals Borda, influential thinker, researcher and sociologist, is noted as one of the founders of participatory action research (Kemmis et al., 2014). Working with a group of researchers from diverse disciplines in various third world settings in the early 70's, a feeling existed amongst the group to combine "heart and mind to propose techniques and procedures that would satisfy (their) anxieties as citizens and as social scientists" (Fals Borda, 2007, p. 157). This "feeling-thinking contingent" (Fals Borda, 2007, p. 157) was involved in different projects at the time, from working with peasants in India to confronting dictatorship in Brazil and from decolonizing the social sciences in Mexico to studying local talent in Tanzania and struggles against large land ownership in Columbia

(Fals Borda, 2007). What did connect the diverse group, however, was a desire to abandon university routines and a dedication to alternative forms of research (Fals Borda, 2007). While this is noted as the beginnings of participatory action research, McNiff and Whitehead (2011) suggest that his term may be seen as tautological as all action research is participatory in nature.

In his approach to action research, Fals Borda's (2007) identified three 'strategic tensions' between a) theory and practice, b) subject and object and c) worldview and the value orientation (Fals Borda, 2007).

The theoretical-practical tension is twofold. Researchers can work without an *a priori* hypothesis or pre-established practices but rather with a "slow rhythm of reflection and action which would allow making adjustments along the path of transformation … as needed, with the participation of the base actors" (Fals Borda, 2007, p. 159) much like the work of design thinking. This work is guided by clear ethical-political principles and as Fals Borda (2007) explains, "(p)axis cum phronesis, telesis or purpose became the minimum desirable ethical framework of the staff and investigators in the field" (p. 159). Secondly, this theoretical-practical tension suggests that the criteria for validity rest on the results in the field, local impact, and with the perceptions of the local groups or base actors (Fals Borda, 2007).

In considering the subject-object tension, the researcher and the researched are considered "connected to each other by feelings, rules and attitudes, with diverse opinions and experiences that could be taken into account in the projects(,)…shortening the distance between superior and subaltern, between oppressor and oppressed, exploiter and exploited" (Fals Borda, 2007, p. 160) thus combining different knowledge into different forms of dialogue to inform the research itself.

A third tension exists between worldview and orientation. The Eurocentric worldview of the typical academic often conflicts with the local or regional worldviews of immediacy and everyday life. Developing empathy, by way of adopting democratic and direct participation from within the community, results in a shift of worldview away from the Eurocentic toward the regional (Fals Borda, 2007). Overall, these tensions - theory-practice, subject-object, and worldview-orientation- constitute the heart of participatory action methodology.

About this same time in the UK, action research continued to take hold in education through the work of Lawrence Stenhouse, a founding member of the Centre for Applied Research at the University of East Anglia in the United Kingdom. Stenhouse regarded teaching and research as closely related and called on teachers to become extended professionals by "reflecting critically and systematically on their practices as a form of curriculum theorizing" (McNiff, 2013, p. 58). Educational researchers were seen to be a support for teachers in this endeavor (McNiff, 2103). Importantly, "teachers were not yet encouraged to explain their own epistemological and social commitments in improving their practices" (McNiff, 2013, p. 59). However, current research suggests the importance of positionality, as "the *way* in which we know is most assuredly tied up with both *what* we know and our *relationships with our research participants* [emphasis in original]" (Lincoln et al., 2011, p. 123) creating an intersect between the acknowledgment of epistemology and ethics in research (Lincoln et al., 2011).

Stenhouse's ideas were further developed through John Elliot and fellow researchers at the Centre for Applied Research (McNiff, 2013). According to McNiff

(2013), Elliot argued that in action research general ideas should be allowed to shift rather than be fixed in advance, reconnaissance should involve ongoing fact finding rather than simply preliminary work, and action should be well implemented before it is evaluated. This group of researchers eventually broke off into different directions and developed their ideas in different contexts, resulting in the further creation of a family of action research approaches (McNiff, 2013).

Action research families. Reason and Bradbury (2008) describe action research as a family of approaches:

> A family which sometimes argues and falls out, whose members may at times ignore or wish to dominate others, yet a family which sees itself as different from other researchers, and is certainly willing to pull together in the face of criticism or hostility from supposedly 'objective' ways of doing research. (p. 7)

Across these families, there is general agreement that 'action' refers to taking action to improve practice, and that 'research' involves creating new knowledge as to why and how something has happened (McNiff & Whitehead, 2011). These families differ, however, in regards to the balance between taking action and research in that some families will emphasize a solid research base for the action more than others (McNiff & Whitehead, 2011). A further key issue concerns "the politics of theory – who counts as a knower, who is able to offer explanations, about what, what counts as knowledge, and who makes decisions about these things" (McNiff & Whitehead, 2011, p. 14). While one subgroup of action research families suggests the proper way to do action research is for an external researcher to watch and report on the practitioner, generally referred to as interpretive action research, the second subgroup posits that the practitioner is able to offer their own explanations for what they are doing and is often referred to as living theory action research, self-study or first person action research (McNiff & Whitehead, 2011).

Among these families, Kemmis et al. (2014) suggest that there are three different purposes of action research that differ in the ‘teleo-affective structure’ or the purpose and structure for people involved: technical, practical and critical action research. Technical action research aims to control and improve outcomes and practice as a means to an end. In this approach, the intended outcome is known and the focus remains on the practitioner (Kemmis et al., 2014).

Practical action research is “guided by an interest in educating or enlightening practitioners so they can act more wisely and prudently” (Kemmis et al., 2014, p. 14). In a practical action research approach, the outcomes cannot be known in advance. The practitioner decides what is to be explored and what changes are to be made, but is open to the views of others. Participants are seen as capable of speech and action and their views and experiences are seen as valuable.

Critical action research is “guided by an interest in emancipating people and groups from irrationality, unsustainability, and injustice” (Kemmis et al., 2014, p. 14). Critical participatory action research seeks to transform not only activities and their immediate outcomes (as in technical action research), or the persons and (self-) understandings of the practitioners and others involved in and affected by a practice (as in the case in practical action research), but the social formation in which the practice occurs (Kemmis et al. 2014, p 15).

Ontologically, action research is concerned with states of reality that are dynamic and changeable by human agency (Nicholas & Hathcoat, 2014b). Additionally, the action researcher, "through reification, actively aims to bring new realities into being" (Nicholas & Hathcoat, 2014b, p. 571). This aim to change reality is value laden (McNiff & Whitehead, 2011; Nicholas & Hathcoat, 2014b) and morally committed (McNiff & Whitehead, 2011). Further, action-research occurs in the company of others and whose influence, past or present, is evident (McNiff and Whitehead, 2011). How researchers view participants and how participants view researchers will affect the outcome of the research (McNiff & Whitehead, 2011).

Epistemologically, engaging in action research assumes that not all knowledge is necessarily knowable as it is in a constant state of flux (McNiff & Whitehead, 2011). Knowing is tentative and problem focused (Hathcoat & Nicholas, 2014a). Further, knowledge creation is a collaborative process and so, while as the teacher-researcher, I have investigated my own practice, this was done in collaboration with the ideas and knowledge of others (McNiff & Whitehead, 2011) through drawing upon the literature and advice from the supervisory committee, and other practitioners in my school.

As per Carr and Kemmis (1986), the two essential aims of action research as a critical educational science are to improve and to involve. To do so, educators may choose to engage in practitioner action research, as is the case with this study. Practitioner action research, being practical in its teleo-affective structure (Kemmis et al., 2014), entails studying local practices, focusing on teacher development and student learning, implementing an action plan and leads to the teacher-as-researcher (Creswell, 2015). Practitioner action research holds the following assumptions about the role of the teacher as a reflective practitioner. Teacher-researchers:

- have decision-making authority to study an educational practice as part of their own ongoing professional development
- are committed to continued professional development and school improvement
- reflect and act in order to improve their practice
- use a systematic approach for reflecting rather than a random design
- will choose an area of focus, determine data collection techniques, analyze and interpret data and develop action plans.
- actively engage all stakeholders in order to inform understanding and subsequent actions. (Creswell, 2015)

In the spirit of appreciating and drawing on the range of diversity of action research approaches and methods as per Reason and Bradley (2008), this research project drew upon the definition of practice offered by Kemmis et al., (2014) where practice is defined as:

> A socially established cooperative human activity in which characteristic arrangements of actions and activities (doings) are comprehensible in terms of arrangements of relevant ideas in characteristic discourses (sayings), and when the people and objects involved are distributed in characteristic arrangements of relationships (relatings), and when this complex of sayings, doings and relatings 'hangs together' in a distinctive human social project. (Kemmis et al., 2014, p. 50)

Furthermore, the practice (sayings, doings and relatings) is held in place by a practice architecture, which can constrain or enable practices. As explained by Kemmis et al. (2014), this architecture must be considered in critical participatory action research and includes the cultural-discursive arrangements (language, ideas), material-economic arrangements (objects, special arrangements) and social-political arrangements (relationships between people). Kemmis et al. (2014) liken the practice and the practice architecture to partners in a dance; neither act as the foundation but rather both shape and react to the other and lead at times. It is my belief, as the teacher-researcher, that these definitions of both practice and practice architectures helped to better focus the examination, questioning, and transforming of personal understandings of my practice, how I conducted my practice and the conditions under which I practiced.

Lewin, as previously noted, suggested that action research “proceeds in a spiral of steps, each of which is composed of a circle of planning, action and fact finding about the results of the action" (Lewin, 1946, p. 206). Kemmis et al. (2014) suggest that, while all of these stages are important, they often progress in a more unstructured way. Further, “initial plans often become obsolete in light of learning from experience” (Kemmis et al., 2014). Mertler (2014) illustrates the processes of action research and highlights specific research activities at each stage in Figure 3.1.

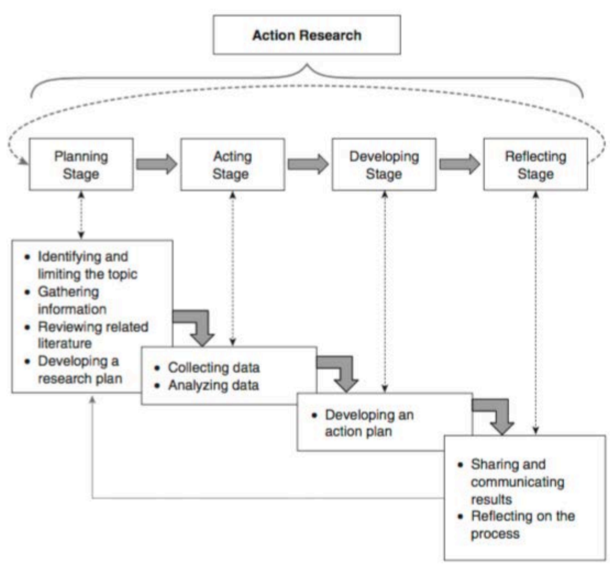


Figure 3.1. The process of action research with specific research activities at each stage. (Mertler, 2014)

The previous components of this work have served a pivotal role in the planning stage of the action research by way of gathering information and reviewing the literature. From this, a plan to move forward with knowledge building principles in a computer supported collaborative environment evolved.

Practitioner Action Research on Designs for Knowledge Building

As noted in the literature review, teaching as design, as described by Goodyear, Carvalho and Bonderup Dohn (2014), is the kind of educational work that sets things in place prior to the learning activity. As the teacher-researcher who was looking to design for knowledge building, I did, indeed, set up the practitioner action research methodology and methods prior to the learning activities. It is important to note that, as a teacher-researcher, who brought more than 20 years of teaching experience across grades 1 to 9, I was also new to this specific school context and, consequently, to these students. The original research design and methods presented in this chapter were designed before I knew who the research participants would be and the context in which I would teach and carry out the study. With action research, multiple data sources, including who the students are and what the context is like, are used to continually strengthen and update the methodology and methods. The original design was modified in response to the complexity and diversity of the context and these participants. The following discussion presents the context and outlines the complexities that resulted in a shift in focus, followed by both the anticipated plans for data collection and analysis along with the actual methods used for data collection and analysis.

Research Context

In effort to build a robust narrative of this actin research, specifically the designs and redesigns, the following section focuses on describing both the research site and the participants in detail.

Research Site. The site of the research is crucial in action research as it is the place where the arrangements between practice and the practice architecture are found (Kemmis, 2014). The following information reflects the research site during the timespan of the research.

The school is located in an urban neighbourhood of a large city. A majority of students lived within the catchment zone resulting in a limited number of students were bused to the school. All teachers lived outside of the school catchment zone. Residents in this community had a median household income of $70,820 in 2010, slightly below the median income across the city. As of 2011, 17% of the residents were immigrants, somewhat lower than the overall immigrant population of 28% across the city (City of Calgary, 2015).

Regarding the physical plant, the building was configured with traditional classrooms and a central library in the process of transitioning to a learning commons with a Maker Space during the time of the research. Initially, the library housed 25 laptops in a computer lab until the midpoint of the year when the lab was dismantled and computers were shared out to all classrooms. From that point forward, each classroom had four iPads, four Chrome Books and at least four PC laptops. Classrooms were all equipped with interactive whiteboards. Outside was a natural space, consisting of hard and soft landscaping, named ‘The Heart Circle’ that had been designated as an outdoor classroom.

During the year of research, the school was staffed with a full time principal and a part time assistant principal. As well, there were eleven full time teachers, two educational assistants, and six part-time support staff. With an enrolment of 190 students from kindergarten to grade 6, the school was described on the school website as a strong community of learners where students and teachers work cooperatively and collaboratively (CBE, 2015). Further, the following beliefs were noted on the school website:

- teaching practice begins with thoughtful and intentional plans for learning
- literacy and technology are interwoven and connected to enrich student engagement
- teachers endeavor for student work to be relevant, meaningful and authentic to excite and engage learners
- Digital Learning Environment has been enhanced to support student learning (CBE, 2015)

Participants. In this action research study, the students in one elementary school classroom defined the sample. This is generally referred to as non-probability sampling, where participants are selected based on naturally occurring groups (Davidson, 2006). Convenience sampling, accidental sampling or opportunity sampling are terms that may be used alongside action research and refer to the idea of using a sample that is convenient to the researcher, such as a classroom or a school (Davidson, 2006). It is important to consider that the results of an action research study in one school may not be representative of the behaviour of all students or classroom communities due to environmental, cultural, or socio-economic factors and caution is advised in generalizing results that rely on convenience sampling (Blackstone, 2012).

This action research study was conducted in a small elementary school in a large urban center. The grade 3-4 class, the site in which the research was conducted, consisted of twenty-four students ranging in age from eight to ten years old. These students were diverse in regards to cognitive abilities; one-third of the students had been previously assessed and met the criteria for special education learning codes from Alberta Education. A small number of students were awaiting assessments to diagnose learning difficulties. English language learners accounted for one-third of the population of the class, and presented with varying degrees of language proficiency in reading, writing, speaking and listening. Classroom supports, specifically educational assistants or additional resource time, were inconsistent in terms of the person providing support and the amount of time provided. Because it was a multi-aged classroom, the grade four topics were explored in science and social studies. Language arts and math task designs were based on current levels of achievement, determined by way of pre-assessment and ongoing formative assessment, and grade level outcomes provided in the provincial curriculum. Based on the demographics of the school in general, along with past experience in teaching settings, I would suggest that this classroom setting, and thus the site of the research, had a higher degree of complexity than might be anticipated in similar school settings.

Ethics approval from the Board of Education was received in November, 2016. Student assent and parent consent forms, both of which were necessary for participation in the research, were distributed by the graduate supervisor in December, 2016. These forms sought permission from parents and from students to use student work beyond classroom level assessments in the data analysis process. Returned forms were sealed and stored by the graduate supervisor until the end of the school year. The use of an external researcher to obtain consent ensured that I, as the teacher-researcher, would not be aware of participants versus nonparticipants in the research and was enacted to reduce potential for soft coercion or perceived inequality of treatment. In all, 22 of 24 students provided assent and 18 of 23 parents/ guardians provided consent. Therefore, I was able to draw upon data from the 18 participants from whom I had both student assent and parental consent for research participation. To reiterate, knowledge building was an approach used with all students in that it was appropriate work given the current educational initiatives at the local and provincial levels. However, the student work used for the purposes of data analysis for this research came from only those students who had consent and assent.

As noted, a key assumption of practitioner action research is that the teacher-researcher is also a participant. Going into this research, I had been a teacher in the public school system for twenty years, working with students from kindergarten to grade nine in a variety of settings, as well as a literacy support teacher in specialized settings for students with identified learning disabilities in the areas of reading and writing. As a participant in the research, I used ongoing journaling to document my participation. This journaling included reflecting on my practice, particularly my sayings, doings, and relatings, along with that defined my practice.

Collection of Evidence

In action research, Kemmis et al. (2014) suggest that we are “not so much interested in *data* (the scientists’ word) as we are in *evidence* (the historians’ word). We gather evidence of the impact of our actions to “show us how we are doing and whether we are getting better than before” (Kemmis et al., 2014, p. 67). The purpose of gathering evidence is to “feed and nurture self-reflection about our practices, our understandings of our practices, and the conditions under which we practice” (Kemmis et al., 2014, p. 68). Accordingly, the following section outlines the original plan for collecting and analyzing evidence, specifically those practices that involved moving forward for knowledge building, in the action research cycle. Originally, it was anticipated that evidence would come from document analysis, narrative analysis, and observation and journaling. In reality, due to the complex nature of the classroom, evidence came from observations, narrative analysis of student contributions to GAFE, and journaling.

In this practitioner action research study, the collection of evidence included written observations, audio and video observations, photos, teacher reflective journals and student contributions to knowledge building. Student contributions were made digitally in Google Applications for Education, verbally, and in physical document form. All data was collected with the original intention of exploring the following research question: What learning designs enable a class of students to engage in knowledge building? The intended study further involved understanding:

1. How do students engage with knowledge building principles?

2. How can scaffolds support participants- students and teacher- as they engage in knowledge building in computer supported collaborative learning using Google Applications for Education?
3. What literacy practices do participants engage in as knowledge builders?
4. In what ways can a knowledge-building model influence students' current epistemic cognition?

However, due to the aforementioned diversity of learners in the classroom and the complexities present in the school environment, there were fewer than anticipated opportunities to engage in data collection, including semi-structured observations. Insufficient data was collected regarding (a) literacy practices of the participants engaged in as knowledge builders, (b) observations regarding metacognitive knowledge, metacognitive judgments and self-regulation for the purpose of analyzing current and shifting epistemic cognition.

As a result, the study was narrowed in its focus to an emphasis on understanding (a) how students engage with the knowledge building principles as defined by Scardamalia (2002); and (b) the quality of scaffolded discourse in computer supported collaborative environments. However, the study also took on an additional focus as students engaged with the design thinking initiatives set forth by the local Board of Education. As students began to engage in design thinking initiatives, the commonalities noted between the processes for design thinking and the knowledge building principles and scaffolds were noted; design thinking was noted as relevant to the work of knowledge building and, as the teacher-researcher, I decided that more consideration of these connections would be appropriate. The study expanded to include understanding the ways in which a design thinking approach to education, as defined in chapter two of this work, might support or complement knowledge building for students. In the literature review, design thinking is defined as a system of overlapping spaces: inspiration is the problem or opportunity that motivates the search for solutions; ideation is the process of generating, developing, and testing ideas; and implementation is the path that leads from the project stage into people's lives (Brown and Wyatt, 2010). This shift resulted in a new research focus: In what ways can a design thinking approach to education support knowledge building? In sum, this study sought to better understand the following: What learning designs enable a class of students to engage in knowledge building? The study further involved originally understanding:

1. How do students to engage with knowledge building principles?
2. How can scaffolds support participants- students and teacher- as they engage in knowledge building in computer supported collaborative learning using Google Applications for Education?
3. What relationships exist between knowledge building and design thinking?

Four action research cycles were implemented over the year, each of which is referred to in this study as a knowledge building initiative. Each of the knowledge building initiatives lasted between 8 to 12 weeks. These knowledge building initiatives were, in part, based on the curricular content areas of the grade four science topics identified by Alberta Education: 1) Plants and Plant Growth, 2) Light and Shadow, 3) Simple Machines and Building Devices that Move, and 4) Waste in our World. The choice to use the science topics to guide the action research was twofold. First, as the teacher-researcher, while I acknowledge that theory generation happens across disciplines, it was within the subject areas of science that I felt most comfortable in beginning the work of theory generation with my students. Second, past experience has shown that each topic is generally allotted about two months in the year for exploration, which I determined was an appropriate amount of time to design, implement and analyze that would allow for multiple iterations of knowledge building initiatives over the school year. However, it is important to note here that Bereiter and Scardamalia (2014) advise that:

> Instead of "doing" knowledge building in selected subjects at selected times, students should always be alert to the possibility of better ideas, better explanations, better ways of doing things, never quite satisfied with final answers, always looking for opportunities to design and redesign and to act on the basis of well-constructed ideas and understandings. (p. 39)

The science modules were not intended to be the main work of knowledge building. In attempt to support students to become alert to the possibilities noted above and to never be quite satisfied with final answers, further opportunities to engage students in knowledge building alongside the science initiatives were sought and designed for when and where possible as the academic year progressed. These further and ongoing opportunities were referred to in this work as concurrent opportunities.

Teacher Designs

This following provides a description of the teacher designs that were implemented and why over the school year to allow the reader to better understand how evidence was generated. As the teacher designs were enacted, these were subject to an inductive approach to analysis. This included looking for patterns in the evidence collected and then reflecting on both the processes and the consequences of those processes. This analysis and reflection occurred with each new knowledge building initiative, about every 8 to 12 weeks. Analysis and reflection were followed by re-design for student engagement with knowledge building principles and scaffolding for knowledge building discourse, both face-to-face and in the computer supported collaborative environment. The following section outlines, in detail, the designs and redesigns that were implemented over the course of the school year.

Knowledge building initiative one: Plants and plant growth. This first knowledge building initiative stretched from early October, 2016 to late November, 2016. Knowledge building "begins by getting students on sufficiently intimate terms with the object to be understood that they can ask some *why* questions with some meat" (Bereiter, 2002, p. 126). Jåravelå and Renninger (2014) suggest that, design should attempt to trigger interest in content through novelty, challenge, surprise, complexity or uncertainty and that, further, design needs to make connections between the real world and the content to be learned.

In an effort to allow students to become familiar with the Plant and Plant Growth topic so that they might begin to ask questions, the following activities were designed at the beginning of this knowledge building initiative. Students were introduced to the unit with a variety of video clips exploring the current work in the discipline. For example, NASA scientists are currently examining how plants grow in space and how this can inform our work on Earth with plant growth in less than ideal environments. Books were brought into the classroom for students to read and explore, additional videos were shared and time was spent in the outdoor learning space, observing and sketching. Plants were brought into the classroom for observation and care, and for use in art projects. A field trip to a local educational venue allowed for participation in a program entitled 'Becoming a Botanist' and presented an opportunity for students to participate in a variety of center activities to explore ecosystems. On this trip, students designed a plant capable of living in a given ecosystem, and took a guided nature walk. These activities were more heavily planned for at the beginning of the initiative but continued throughout the entire span of the initiative when and where appropriate.

Back in the classroom, the question, 'How do plants grow?' was introduced to the students as a way of introducing and exploring theory generation with students. Discussions with students centered on understanding that theories are explanations for phenomena and that these explanations can be tested. Originally, the student theories were recorded on Post It® notes and adhered to the large whiteboard at the front of the class. Post It® notes were used as a way to begin to engage students in knowledge building as the computer technology was unavailable at that point due to beginning of the year maintenance issues. Additional coloured Post It® notes were introduced each day. Each different coloured Post It® note represented one of the following scaffolds used as prompts: I need to understand…, My theory…, New information…, A better theory…, This theory does not explain…, Putting our knowledge together…. These prompts were used as they have been found to effectively guide student discourse and to support the process of in Knowledge Building in various contexts (Cacciamani, 2010; Moss & Beatty, 2010; Sun, Zhang, & Scardamalia, 2010; Zhao & Chan, 2014).

As students generated theories and identified what they needed to understand, they were also asked to find new information using resources available, including books, videos, experiments or living plants. Students were asked to add to the whiteboard by using the scaffolds used by 'I need to understand…" and 'New information…' with different coloured Post It® notes for each scaffold.

It is important to note that, while the scaffolds were made available to support student understanding, verbatim use was not mandated. The rationale for this pedagogical decision was that knowledge building is principled rather than procedural and therefore, students were encouraged to apply the principles rather than follow prescribed procedures.

As a group, we referred to this visual representation using Post It® notes as a way of noting idea diversity and sharing new information. Students were observed adding ideas to the board; with this first knowledge building initiative students were rarely observed viewing the board. When asked if anyone had taken time on their own to look at the board, two students replied affirmatively.

During this time, students planted and cared for seeds. At this point, further student-generated questions began to surface, specifically with regards to why some students' plants were growing more than others despite planting the same type of seeds at the same time. Those plants that were growing created excitement among the young botanists compared to the disappointment of those whose plants were growing very little or not at all.

At this time, technology became available for student use. In all, 22 Acer laptops were organized into a computer lab in the Learning Commons. Additionally, four Chrome books and three iPads were assigned to and housed in the classroom.

Students were given one lesson as a whole group regarding log in procedures, both for the school Internet and for Google Applications for Education. Additionally, students were provided with directions regarding how to create, title and share the document. In attempt to address their questions regarding plant growth, students were asked to write, “Why do some plants grow better than others?” at the top of the page and they were asked to generate a theory. They were required to share this document with me, along with at least one other person of their choice. In all, 10 documents were created by students, all of which were shared with me as the teacher; 9 were shared with at least one other person besides the teacher in the classroom community. Throughout all of the learning tasks and activities, students were given time to return to their Google documents, with the intention of adding new knowledge, revisiting older theories to question and revise, and identifying new needs for understanding. As students generated theories, they were provided time to explore new information using resources available, including books, videos, experiments, internet resources or living plants. The principles of knowledge building were introduced and posted in the classroom for ongoing reference. For example, when asked in whole group discussions about their knowledge building, students would identify examples of the principles in connection to their work.

During the science topics, beginning with Plants and Plant growth and continuing throughout all subsequent topics, assessment was ongoing. Anecdotal notes and observations, student contributions to GAFE, student contributions to whole group discussions, project work and sketch notebook entries were assessed for evidence of understanding of concepts, connections between concepts, analyzing and solving problems, skills for inquiry and communication, and exploring scientific events and issues.

Concurrent work in knowledge building: Writer's workshop. In and around mid-October, a writer's workshop structure was introduced to the students and continued to be supported until the end of the year, as various designs were considered and reconsidered to best support students in continually improving their written ideas. As previously noted, Scardamalia and Bereiter (2014) advise that students should always be alert to the "possibility of better ideas, better explanations, better ways of doing things, never quite satisfied with final answers, always looking for opportunities to design and redesign and to act on the basis of well-constructed ideas and understandings" (p. 39). Routines were designed and established to support these possibilities for further enculturation into knowledge building. One of these opportunities presented itself in the writer's workshop block.

During this writer's workshop block, students were organized into small groups. They were asked to provide a list of people with whom they felt they could work well and they were organized based on their choices and teacher discretion. The intention of these small groups was to provide ongoing opportunities for students to assess the state of their work and to call on their group when necessary in order to discuss possible opportunities for idea development, all in attempt to build epistemic agency among the students. As part of the work, thinking routines, as scaffolds, were introduced. Thinking routines are

> simple structures, for example a set of questions or a short sequence of steps …(that) get used over and over again in the classroom so that they become part of

> the fabric of classroom' culture. The routines become the ways in which students go about the process of learning. (Project Zero, 2016, n.p.)

These thinking routines, as they were new to the students, were modeled and practiced with a large group before students were asked to use them in their smaller groups in hopes that the students would be more successful in using the thinking routines independently having practiced together. In this, the thinking routines involved students coming together each day as a group to improve ideas by asking, *Does anyone need time to share their work?* If there was a need, the author would have to identify what she needed support with before reading her work and the feedback from the group would be based on the specified need. For example, students often requested, *"I need to know more ideas for the plot"* or *"I need some juicy words"* as possible opportunities for idea improvement and acknowledging the classroom community as a resource. Throughout the year, students were assessed, in part, on the ongoing development of their written ideas. While they were not obligated to apply the ideas for improvement offered by peers, the feedback from peers often provided specific ways to improve writing and offered opportunity to develop writing in specific and appropriate ways based on curricular outcomes.

Concurrent work in knowledge building: Mathematics. A part of the overall math program, students were provided with multiple opportunities each week to work with questions that allowed for multiple responses. These questions, referred to as open-ended questions, were designed to uncover student understandings and misunderstandings, and to differentiate math instruction (Small, 2009). In providing this opportunity to students, it was hoped that students would begin to see math as more than one correct answer, but as an opportunity to view the body of knowledge as more complex, interrelated concepts and the possibility of better ideas, better explanations, better ways of doing things, never quite satisfied with final answers. Examples of an open-ended question used in class include the following.

1) *Describe a time where a number definitely tells how many.*

   Describe a time when you are not sure.

2) *25 and 50 – What's the same and what is different about these two number?*

3) *Write an addition question using the word 'less'.*

Open-ended questions were used throughout the year. Modeling was provided to support students who were unfamiliar with this type of questioning and students worked with increasing independence as the year progressed. Responses were consistently shared with small and large groups to allow students to see variety in responses.

Concurrent work in knowledge building: The physical designs of the classroom. Goodyear et al. (2014) remind us that the design of the physical setting is important. From the beginning of the school year, the classroom was consistently designed to promote the development of community knowledge. Desks were organized into small groups. A large space was available for the class to gather for knowledge building talks. Initially, the technology was housed in the library, with a collection of 23 PC laptops organized into a sort of a computer lab. In December, this organization shifted, based on a whole school decision and an ongoing transition from a library to a learning commons. Laptops were disseminated to each classroom, with each room receiving three laptops. At this time, the technology inventory in the classroom included four Chrome books and four iPads along with the three laptops.

By January, unclaimed laptops were adopted into the classroom for a total of fourteen laptops, including the teacher assigned laptop, to which the students often had access. Technology was stored openly and was readily available for students. Physically design of laptop storage was limited due to electrical outputs available in the class. However, in designing the physical space, technology was spread around the room and openly available to all. Earlier in the year, the physical design involved technology behind the teacher's desk, simply due to the location of electrical outlets. To alleviate the potential impression that, as the teacher, I was 'in charge' of the technology, the teacher's desk was relocated so that it was well separated from technology. There were no sign out procedures; students were encouraged to access technology when necessary. The expectation was that, if using technology, students should be able to explain how the technology was supporting the next steps for learning at any given time. Students were invited to bring their own devices to school. During the course of the year, three students brought technology: an iPhone, a tablet and a Chrome book.

Early on in the year, students received one group lesson on how to sign onto school computers, how to sign on to Google Documents and how to create a document to share. Some students were familiar with the process; others struggled with these steps. For these students who struggled, one-on-one support was provided, either from myself, the school principal, or by peers who self-identified as experts.

Knowledge building initiative two: Light and shadow. This knowledge building initiative began in mid-November, 2016 and continued until mid-January, 2017. Students began this knowledge building initiative by engaging in eight different activities that allowed them to play and experience a variety of phenomena related to light and shadow. These activities are attached in Appendix E. Generally speaking, students are asked to complete experiments in class where the outcome is known. Rather than inviting students to complete these experiments as part of the unit outcomes, the design involved flipping this, so that the activities were prepared ahead of time and students explored and played with these experiments; the rationale behind this design was to trigger interest and surprise in the phenomena (Jåravelå & Renninger, 2014).

After two class periods of exploration, we talked, as a large group, about the questions we had because of the explorations. Students were asked to create pages in Google Documents with the question ‘How do we see?’. The students and I decided that this question encompassed all of the specific questions the students had raised. Some students worked independently and created one page; other students worked in groups and created one page. The choice to work independently or with others was based strictly on personal preference. The students were asked to share the document with partners. Students were given time to explore with books, Internet and video. An ophthalmologist and photographer visited the classroom, bringing a slide show and a variety of equipment for the students to explore. Students created shadow puppet shows using a variety of opaque, transparent and translucent material.

At about the same time, students were invited to complete a task called “Knowledge Rating Vocabulary” where they were given numerous scientific terms related to light and shadow and asked to rate their knowledge of these terms, with a one representing ‘I’ve never heard this word before’ to a four, which meant ‘I know this so well I could teach it’ and with the four, they were asked to provide an explanation of the word (see Appendix B).

In this second knowledge building initiative, students continued to use the scaffolds ‘My theory is,’ ‘I need to understand,’ ‘New information,’ ‘A better theory is,’ ‘This theory does not explain,’ and ‘Putting our knowledge together.’ They were asked to create and to share a Google document with others and with me, as the teacher, they had done in the previous knowledge building initiative. Additionally, as the teacher-researcher, I added the scaffolds to all student pages for ongoing reference. This shift in the design was in an effort to emphasize the purpose of the tool and to provide immediate access to scaffolds as students worked.

In all, during this knowledge building initiative, 17 documents were created by students; 15 were shared with at least one other person in the classroom community. Throughout all of the learning tasks and activities, students were given time to return to their Google documents, with the intention of adding new knowledge, revisiting older theories to question and revise, and identifying new needs for understanding. Generally speaking, data analysis should progression in student work with knowledge building principles and supporting knowledge building scaffolds. This progression is discussed in detail in subsequent sections, where growth is compared over the entire academic year.

Concurrent work in knowledge building: Social studies. Designing for continual improvement of ideas in social studies began late October and was ongoing until the end of the year, as various designs were considered to support students in continually improving their ideas. These designs included critical challenges and the introduction of thinking routines to support students in contributing knowledge to the community.

At this time, critical challenges were introduced to the group and this teacher design continued over the course of the year in attempt to engage students in collaborative, creative and critical thinking. Critical challenges were designed in attempt to engage students in making reasoned decisions about puzzling situations embedded in curricular content. Students were invited to consider plausible alternatives to a challenge and make meaningful choices based on clear criteria chosen by the community (Gini-Newman & Case, 2015). For example, students were asked to consider if naming the Royal Tyrell Museum after Joseph Tyrell was an appropriate choice for this important centre of Alberta's fossil heritage and, further, students were asked to consider who deserves to own rare natural fossils and sacred objects? Student-generated criteria was used to justify decisions. These decisions were revisited, reconsidered and refined as more information became available. Further to the above example, students, working in small groups, were asked to brainstorm qualities we would want associated with museum. Curiosity, bravery, loyalty and cautiousness were among the criteria noted by students. Students made decisions based on initial readings and were then asked to revisit their initial decisions after further information gathering.

During all social studies topics, formative assessment was ongoing. Anecdotal notes, observations, student contributions to critical challenges and whole group discussions, presentation work and sketch notebook entries were assessed for evidence of expanding skills connected to the processes for inquiry and research, and effective and informed communication of ideas.

Concurrent work in knowledge building: Design thinking. Design thinking presented further opportunity for students to generate theories and to continually improve ideas based on prototyping and testing (Koh et al., 2015), Students engaged in opportunities for design thinking with literature connections in late November, 2016.

Specifically, students had been listening to a novel during for a given amount of time each day during the literacy block. As the teacher, I was reading aloud and students were engaged in various activities to demonstrate comprehension. In one activity, students designed a way for a character to overcome an identified obstacle. In this work, students used the framework where they ideated, prototyped, tested, redesigned, and retested, allowing for improvement of ideas. Students used sketch notebooks, blocks for building, computers and any other materials they deemed necessary. Ideas were shared in groups of two or three, where one person presented their idea and the other students asked questions for consideration. A protocol for questioning students in regards to their design thinking is attached as Appendix C.

Concurrent work in knowledge building: Redesign of the writer's workshop. Data was used iteratively to inform my teacher designs, to reflect on what was working well, and what needed to change to better support knowledge building. At this point in time, the classroom timetable was redesigned to intentionally allow time at the beginning of each day for students to either read or write, either with a buddy or independently, and completely driven by student choice. This design was in contrast to previous whole school organization where students were required to follow a very structured approach to reading and writing on a daily basis. The intention with the redesign was to provide students with more choice in activity in hopes of increasing engagement (Allington & Gabriel, 2012; Fletcher, 2017). This reading/ writing time was provided as part of a larger literacy block of time.

Additionally, it was observed that students were struggling in the previously introduced opportunities to work in small groups and to implement the thinking routines.

For example, audio recording of group sessions suggested that students were less focused on idea improvement and more focused on chit-chat. As a result, the associated participant structure was redesigned. Students shifted from working in student and teacher selected small groups toward working in a whole group setting. The intention was for me, as the teacher, to increase support by way of further prompting, guiding and modeling the scaffolds and thinking routines previously introduced. Specifically, this involved intentionality in regards to sharing and idea improvement, whereby students noted where ideas or support was needed from the community to help improve the work. Feedback revolved around this request as opposed to more general sharing structures revolving around likes and dislikes about the writing.

When students needed to access community knowledge, they added their names to a list on the board. When addressing the community, the young authors continued to consistently identify what it was that they needed from the community. This design was a continued attempt to move away from sharing the writing to intentional idea improvement.

Knowledge building initiative three: Simple machines and building vehicles and devices that move. This knowledge building initiative began in mid-January, 2017 and lasted until mid-April, 2017. Students began this initiative with exploration. Through a variety of centers, video games, and knowledge rating, along with introductory videos on simple machines, students were asked to create theories about how machines make work easier. Students engaged in further theory generation by participating in a walk-through of the school environment to identify objects they thought were simple machines. Students engaged in building and testing with a variety of materials in and out of the Maker Space. This Maker Space, created midway through the year based on decisions made by teaching staff, was located in the Learning Commons and was set up to provide students with a space filled with a variety of materials with which to build and create in response to identified problems. A field trip to the science center provided students with further opportunity to engage in a design challenge with simple machines.

Rather than inviting each student to create and share a Google document to record ideas for this knowledge building initiative, one document for each of the simple machines was created by me, as the teacher, and shared with all students, resulting in a total of seven documents created and shared to all users. This evolution in using Google documents was in an attempt by me, as the teacher, to provide a central location for the community knowledge as opposed to many individual documents in the previous initiatives. The knowledge building principles were revisited with an emphasis on rise above as a goal for the community knowledge.

After the initial exploration stage, students were asked, as a whole group, to share what they felt that they needed to understand. After the whole group discussion, students uploaded their questions into the Google documents, with many using the scaffold ‘I need to understand.’ The Google documents were discussed as a whole group. The concept of epistemic agency was revisited, emphasizing that students can take on the responsibility of deciding next steps to help them with the identified needs for understanding. Students were given time to explore and record further understandings based on their own work and what they felt the need to understand.

Before searching for further information, the student were provided with a mini-lesson on how to best search Google and how to tell if a website was credible. This involved direct instruction regarding how to search the Internet using a minimum of three search terms to narrow the results of the search. This further involved developing criteria for credibility of sources, including expertise, corroboration and reputation of source and practicing with sample texts. At this time of the year, it was observed that several students began using more specific terms when searching the Internet and, as a result, narrowing the search results; however, a limited number of students began to refer to information as corroborated or to note the expertise.

Concurrent work in knowledge building: Design thinking. At this point, students moved into a design thinking initiative, which invited them to design, prototype, test and redesign a moving device in response to a student-identified problem. This design task was taken directly from the Alberta Education Science Program of Studies (1996), which stated that students were to: 1) construct a machine for a designated purpose, and 2) explore and evaluate variations of the design. Students worked in the Maker Space over several days with designated purposes they had selected, either in self-selected small groups or individually. While a few students identified problems quickly, many students struggled. Those who identified problems quickly tended to be the students who were academically stronger. The struggle with the majority of students was evident in that they voiced that they did not have any ideas and therefore, did not know what to make.

The design problem was then presented differently for those struggling students; for example, they were asked to consider designing something for their favorite stuffed animal that might solve a problem. This change in tactic resulted in, for example, students designing a type of elevator to move a stuffed animal from a top to a bottom bunk, or a way to transport their favorite object to and from a friend's house, or to create a boat to allow the toy to stay dry in the water. Most students designed in response to this second prompt.

Meetings were held in class each day to provide opportunities for the community to ask questions of each other regarding further understandings, to make suggestions for better designs, or to incorporate new information and put knowledge together. The knowledge building scaffolds 'My theory is,' 'I need to understand,' 'New information,' 'A better theory is,' 'This theory does not explain,' and 'Putting our knowledge together.' were continually used as a structure for the community, both verbally as well as in writing. A protocol for questioning students in regards to their design thinking is attached as Appendix C.

Concurrent work in knowledge building: Social studies. Thinking routines were also established in social studies in attempt to engage students in ongoing idea improvement. As the teacher, I led whole group discussions with students and purposely integrated the same knowledge building scaffolds that were being used in GAFE. For example, when students asked questions, they were asked to express their theories whenever possible rather than be provided with direct answers. Class presentations were designed in such a way that they were not considered the final project. Rather, they were an opportunity to bring the current state of the knowledge to the group and for the group to specifically use the same knowledge-building scaffolds to participate in the discussion that were used in the GAFE. For example, students asked each other questions by way of stating, 'I need to understand…' and conversations in response involved questioning students on current theories. Students were asked to follow up with the questions by searching sources and then reporting back to the group. These thinking routines were consistently modeled, prompted and supported until the end of the year.

Knowledge building initiative four: Waste in our world. This last initiative began in mid-April, 2017 and lasted until the end of June, 2017. We began this topic of study by intentionally connecting the previous design topic to Waste in our World, with videos of people who designed solutions in response to problems associated with waste. This included looking at local initiatives as well as international projects. As a class, we worked as a whole group to define ‘our world’ as it related to us as members of families, as students in our school and as citizens of our city, in hopes of triggering interest by making connection between real world and the topic (Jåravelå & Renninger, 2014).

In whole group discussions, we examined our school data, provided by the head office of the school board, to understand how much waste we produce as a school in comparison to other schools in our system. Further, we closely examined the waste generated by our school on a daily basis by dumping the trash bins, taking photos and making notes as a way of observing and documenting our findings.

We invited an expert into the classroom to discuss landfill design, and followed up with a day at the local landfill with an expert, looking at the process of building a landfill, current problems involved in city landfills, and the current initiatives around the local green cart composting program that was about to be initiated citywide. Through active reflection and whole class discussions about these learning opportunities and resources, students were asked to identify the source of the waste that was most worrisome for each of them personally. Students were asked to engage in the design thinking process in response to their concerns. Specifically, they were asked to create a design plan that would address their greatest concern from those identified. Students were able to work in groups or independently, with the understanding that there would be opportunities along the way for whole class discussion using the knowledge building scaffolds. Students were asked to work in GAFE and share their documents with those who would provide further input, again using the knowledge building scaffolds. Designs ranged from the practical to the impractical. In all, eleven documents were created; all were shared with at least one other person along with me, as the teacher, in the classroom community.

Concurrent work. From April to June, concurrent work continued in social studies and writer's workshops as described in the previous initiative. Students continued to work using the scaffolds when appropriate with more independence and less prompting.

Computer supported collaborative learning (CSCL). CSCL research "focuses on meaning making practices of collaborative groups and on the design of technical artefacts to mediate interactions" (Stahl et al., 2014, p. 496). As well, CSCL seeks to identify explore the unique advantages of computational media, how collaborators use these and how they influence the course of their meaning making (Stahl et al., 2014). In this work, the media in question was Google Applications for Education. The design involved the use of the knowledge building scaffolds as identified by Scardamalia and Bereiter (2006): My theory is… I need to understand…New Information…A better theory is… This theory cannot explain… Putting our knowledge together. It was of interest to explore how these scaffolds worked in tandem with GAFE to support knowledge building. Rather than focusing on the outcomes of the knowledge building, it was of interest to focus on why those outcomes were achieved (Stahl et al., 2014).

Participants were introduced to the technology, Google Applications for Education (GAFE), and were provided time and support to learn the basics including how to login, how to create and share documents, how to use voice note, how to insert links, images and videos. Students worked concurrently in building proficiency with the tool and with a topic of study mandated by the provincial government.

Observations Within the Knowledge Building Initiatives and Concurrent Work

Generally speaking, observations involve carefully watching and systematically recording what is seen and heard in a particular setting (Mertler, 2016). Observational evidence from the knowledge building initiatives, as well as evidence from the concurrent work in the classroom, was collected during the course of the year as a way of thinking about the existing evidence and how to generate new evidence. Observations were semi-structured in nature, which entailed listing key events that were expected yet left room for the unexpected (McGrath & Coles, 2015). These semi-structured observations allowed for the "flexibility to attend to other events or activities occurring simultaneously in the classroom or to engage in brief, but intense, periods of observation and note taking" (Mertler, 2009, p. 526). This was in keeping with an essential tenet of action research: the classroom action research should never be done at the expense of the classroom itself (Mertler, 2009). The observation protocol is attached in Appendix A.

Observations occurred, when possible, in action by way of paper and pencil field notes, video recording or photographs. When teaching responsibilities excluded the possibility of observations in action, which was often, observations occurred as soon as possible after the teaching, based more on memory than sight. When appropriate, observations were supported by audio or video recording. For example, when working together in whole class conversations, audio records were made and the interactions later analyzed.

Evidence was collected as scribbled field notes or raw audio recordings. These notes and recordings were converted to expanded write-ups or longer, more detailed audio recordings that were then transcribed into text by way of a transcription service, as were any direct audio recordings of field events. As the teacher-researcher, I reviewed and transcribed the video recordings.

In all, observations included 241 photos, 42 videos and 30 written observations. Evidence was imported into qualitative analysis software, NVivo, a qualitative analysis software tool, to organize, and analyze unstructured text, audio, video, and images. All evidence was reviewed numerous times and relevant excerpts were identified for judgment (Miles et al. 2014).

During observations, field notes were taken in a coil bound notebook or audio recorded and sent for transcription into a word document. Each written page was divided into two columns: ‘Observations’ and ‘Observer Comments’. The observations focused on the actions of the participant and the observer comments focused on preliminary interpretations of those actions.

There were key advantages to using observations as a method in educational action research. For example, as the teacher-researcher, I gathered evidence about participant actions, in addition to their thoughts and feeling. A key disadvantage existed in that, in taking on the role of observer and using recording devices, student behaviour may have changed in terms of what they said or did (Mertler, 2009).

Student artifacts. Evidence also came from looking carefully at student-generated artifacts. These artifacts included the student-written contributions to GAFE across all knowledge building initiatives. As noted, students were provided with knowledge building scaffolds in the way of prompts to support their contributions to community knowledge. Further to these digital contributions, student artifacts also included sketch notebook entries connected to knowledge building, design artifacts created in the Maker Space. In all, evidence included 40 student documents in Google Applications for Education and 44 student entries into sketch notebooks.

Journaling. Journaling throughout an educational action research project provided me, as the teacher-researcher, an opportunity to maintain a narrative account of the professional reflections on my practice. Mills, (2007) suggests that journaling allows the teacher-researcher to "systematically reflect on their practice by constructing a narrative that honours the unique and powerful voice of the teachers language" (p. 70) and is perhaps the most important form of evidence collection in action research (Kemmis et al., 2014). It provided me a space to monitor my own thinking and actions, as well as a place to capture how thinking informed actions (McNiff, 2013). Using the definition of practice provided by Kemmis et al. (2014), journaling included reflections on the following: sayings and cultural-discursive arrangements, doings and material-economic arrangements, relatings and social-political arrangements, and reflections on the project of my practice as briefly summarized below.

Sayings and cultural-discursive arrangements. This included notes and reflections on changing uses of language and the development of more coherent discourse, including both my own and others' language and discourse. This also included and the ways I related to the wider context of language and discourse of my workplace and the world around it, including relevant educational literature.

Doings and material-economic arrangements. Notes and reflections were made about changing activities in my setting, including both my own and others' activities, and in relation to the wider context of circumstances, constraints and opportunities in and beyond my workplace.

Relatings and social-political arrangements. These notes and reflections concerned changing social relationships among those involved in this research setting, and any emerging changes to the formal organizational structure —both in relation to myself and to others, including my students and colleagues.

Reflections on the project of my practice. Notes and reflections concerned how I see the project or purpose of my practice changing, and how my commitments (for example, my educational commitments) are changing in the light of what I am learning.

This journal was a reflection on action and occurred after the fact, as opposed to reflection in action. Specifically, reflections were made after school hours as opposed to in situ. Reflections were handwritten as well as dictated using speech-to-text technology. In all, 20 teacher reflections were collected for the purpose of analysis.

Analysis of Evidence

Qualitative analysis involves the "ways in which the researcher moves from a description of what is the case to an explanation of why what is the case is the case" (Hitchcock & Hughes, 1995, p. 295) and should be done concurrently with collection of evidence to allow cycling back and forth between thinking about the evidence and generating strategies for collecting new, often better, evidence (Miles et al., 2014). The intention of this section of the chapter is to detail the analysis procedures that were used with each of the methods previously noted. This analysis informed the developing stages of the action research as informed where the knowledge building was or was not moving forward and where next steps in the iterative cycle needed to be focused.

Narrative Analysis of the CSCL. In using narrative analysis, “the aim is to explain why and how something has happened by means of configuring a series of sequential events that are consequential for what happened” (Fu et al., 2013, p. 32). Narrative analysis has been used in asynchronous environments as opposed to conversation analysis, which is mainly used in synchronous, small group conversations.

Building on the work of Fu et al. (2013) in trying to better understand knowledge building discourse in CSCL, this study employed the use of narrative analysis to investigate how an idea is improved over time through knowledge building discourse in GAFE, specifically using the following scaffolds: My theory is… I need to understand…New Information…A better theory is… This theory cannot explain… Putting our knowledge together. Using this social-cultural approach to study collaborative discourse, the collaborative episodes were the unit of analysis, in keeping with the theory of distributed cognition with a “focus on gaining insights into distributions of cognition across organizations, technologies, and infrastructures and how these social and physical structures mediate collaborative learning activities” (Parchoma, 2015, p. 235). The intended analysis involved the following two stages.

First, the contributions that the students made to GAFE were read to determine if organization in such a way to identify inquiry strands was necessary. That is to say, it was thought that any one discussion thread could have contained reference to multiple inquires or, an inquiry might be addressed across multiple threads. An inquiry thread, for this work, was defined as "a series of notes that address a shared principal problem and constitute a conceptual stream in a community knowledge space" (Zhang et al., 2007, p. 125). However, after reading all discussion threads, it was noted that the way that the students organized in Google documents resulted in discussion threads that contained reference to only one inquiry, so organization was no longer needed as a stage in the analysis.

Narrative analysis was used to analyze the discussion threads to identify meaningful patterns of interaction in relation to idea development. In doing so, each collaborative event was assigned one of the following codes as previously discussed in detail in chapter two: 1) chit chat, 2) idea sharing, 3) idea co-construction and 4) idea development. Table 3 provides a brief description of each code.

Table 3

Description of Codes Used in Examining Quality and Frequency of Scaffolded Conversations in GAFE

Codes based on Fu et al. (2013)	Description of code
Chit chat	brief messages, emoticons, greetings that are not connected to the use of the scaffolds
Idea sharing	sharing of information, facts including images, videos or links to websites relevant to the seed question
Idea co-construction	questions or attempts to engage conversation that are relevant to the seed question
Idea development	at least one explanation event and the

	explanation event must not directly build on the seed question but rather develop beyond the seed as moving the idea progressively forward

Note that the criteria for ‘idea development’ were chosen as Fu et al. (2013) suggest that an inquiry thread containing rich content knowledge coming out of collaborative interactions is the best type of idea for knowledge building.

Observation analysis. In first cycle coding, attempts were made to employ in vivo coding to summarize segments of the evidence. In vivo coding is identified as appropriate for virtually all qualitative studies and as a coding method that honours the participants’ voice (Miles et al. 2014). However, due to the complex nature of the class and the resulting need to write observations after school rather than in situ, observations mainly consisted of retelling and paraphrasing from my perspective as teacher-researcher, along with photo evidence as opposed to direct student voice.

From this attempt at in vivo coding, theoretical frameworks were used for observation analysis in an attempt to bring order, structure and meaning to the mass of collected evidence (Marshall & Rossman, 1990). Provisional codes for analysis were derived from a) the knowledge building principles and b) the Social Infrastructure Framework.

In these approaches to coding, deductive codes were used. The knowledge building principles were used first as codes and applied across all evidence collected, including photos, reflections, observation and student work. The knowledge building principles characterize the social-cognitive and technological dynamics of knowledge building and included real ideas, authentic problems; idea diversity; improvable ideas;

epistemic agency; community knowledge, collective responsibility; democratizing knowledge; symmetric knowledge advance; pervasive knowledge building; constructive use of authoritative sources; knowledge building discourse; concurrent, embedded, transformative assessment and rise above (Scardamalia, 2002). These principles facilitate the enactment of classroom innovation and can inform the practices of teachers (Fu, van Aalst & Chan, 2016). To better understand how students engaged with knowledge building, an important step was to understand with which principles students engaged, how frequently and in which situations.

Observations were then analyzed with the Social Infrastructure Framework, as it offered access to the social, material, cultural, embodied, and mental richness of activity and learning (Deitrick et al., 2015). These codes were derived from the sub-dimensions of the framework and included conceptions of learning and knowledge, student social identity, teacher identity, purpose of the tool, activities, associated participant structures of students, associated participant structures of teachers, student-teacher-machine-physical space configurations, student-teacher-cyberspace configurations, cyberspace-physical space relations, bringing knowledge in from the outside world, extending the audience for the student work and interacting with others. Using distributed cognition in the analysis of learning can offer insights into how activity, including learning, happens that are not possible within the traditional cognition-is-inside-the-head paradigm. Evidence collected from the observations was used to gain insight into strengths and needs of the participants and was then used to better understand and inform design within CSCL.

This coding process was supported by the use of jottings and analytic memos. Jottings were used to capture any reflections or commentary such as inferences, personal reactions to remarks, doubts, second thoughts, cross-references to other evidence or future ideas to pursue (Miles et al., 2014). Jottings were recorded using the ‘insert comment’ feature on the word processing program or in the margin of the journal notebook.

Analytic memos served as extended narratives of the thinking while coding the evidence. This included notes on any personal connections, emergent patterns, related theory, personal or ethical dilemmas, and future directions (Miles et al., 2014). Jottings were noted in the document itself and formatted in italic font to differentiate the memo from the transcribed text.

From the provisional codes, a second cycle of coding entailed grouping these codes into themes in such a way as to interpret the behaviours, skills and attributes of the students and then to design in response. Transcripts were highlighted and jot notes were added to the margins reflecting any initial ideas, thoughts or reflections to provide a record of the initial sense of the evidence (Bloomberg & Volpe, 2012).

Student artifact analysis. Beyond those digital artifacts in GAFE noted above, that were analysed by way of narrative analysis, physical artifacts were analysed using theoretical frameworks for analysis. As with the observations, provisional codes for analysis were derived from a) the knowledge building principles; and b) the Social Infrastructure Framework.

Journal analysis. As journaling was part of an ongoing routine, it was important to analyze reflections in an ongoing manner in effort to inform next steps in the iterative action research cycle. In an attempt to bring order, structure and meaning to the mass of collected evidence (Marshall & Rossman, 1990), journals were analysed using theoretical frameworks for analysis. As with the observations, provisional codes for analysis were derived from a) the knowledge building principles; and b) the Social Infrastructure Framework. This coding process was supported by the use of jottings and analytic memos in the same manner as outline previously.

Ethical Considerations

Regardless of the type of research, four ethical standards must be met: protection from harm, voluntary and informed participation in the research, the right to privacy and honesty with professional colleagues (Mertler, 2016). Further to this, "as action research has assumed a larger role in education, the need for appropriate ethical guidelines has become evident…. Each role -researcher and practitioner- brings its own ethical standards, and untangling these roles can present knotty challenges” (Zeni, 2009, p. 254). The intention of this section is to discuss these ethical standards and guidelines in detail.

Zeni (2009) emphasizes the ethics of responsibility**.** **“**The ethical standard of *responsibility* **—** the special trust that teachers or other professionals must exercise while investigating issues in their own schools -most clearly distinguishes action research from traditional modes” (p. 257). Further, Zeni (2009) suggests that engaging in educational action research requires the teacher-researcher to consider ethical themes that fall outside of both qualitative and quantitative traditions. The quantitative researcher is an outsider and any personal involvement would be considered biased. On the other hand, the qualitative researcher is involved, albeit in a limited way and relationships are kept in check by anonymity and informed consent (Zeni, 2009). The action-researcher must negotiate a dual role - that of teacher and researcher- that is not present in quantitative or qualitative research. Specifically,

> in classroom action research, the daily activities of teaching assume a dual role ... Meetings with individual students become informal interviews; discussions circles and projects become focus groups; the full range of student work becomes data as well. One ethical question is central: 'Do the research methods support or interfere with my primary professional role?' (Zeni, 2009, p. 258)

Zeni (2009) argues that the “power and interpersonal complexity of the ‘insider’ role do not necessarily create an ethical threat. In fact, the bonds of caring, responsibility, and social commitment that engage action researchers with other stakeholders may be the most appropriate basis of ethical decision-making” (p. 257). Zeni (2009) explores key themes: responsibility and accountability, action and social justice, and caring and respect. She further suggests reflecting on a set of questions associated with each theme that support the action researcher in navigating ethical considerations. These questions are presented and answered in Table 4.

Table 4

Personal Ethics for Action Research

Responsibility & Accountability	
Who else among the stakeholders has an interest in my question?	All stakeholders – myself, students, parents, teachers, administrators (local & system) and community- held potential interest in this question as the intent behind the question was to investigate how to move toward better supporting learners in the knowledge age.
To whom am I accountable professionally?	Professionally, I was and continue to be

	responsible to all stakeholders noted above.
How will I refer my interpretations back for comment so that my work has more than my own perspective?	First and foremost, my interpretations were shared with my student through our knowledge building community discourse. As part of the process, I brought my interpretations to my students and shared, seeking substantiation or disagreement. As well, throughout the process, I sought the student interpretation before I shared my own and then compare to my own interpretation. Further, when possible, I invited administrators and/or peers, research advisor and/or committee into both the research setting and the conversation to substantiate or rebut interpretations.
Whose permission should I seek to pursue this inquiry?	Creswell (2015) suggests that the action-researcher must conduct the research in a way that "is sensitive to obtaining consent and advancing the purpose of the study when all phases might not be initially known" (p. 594). I sought permission from the school system by way of an ethics approval. Then, I sought approval from the students and parents. Parents were asked to sign a consent form on behalf of the students and minors after attending a parent-teacher interview early in the school year, where the research was explained by the graduate supervisor and the consent forms were made available. As well, students were asked for their permission to participate by way of assent, a mandatory requirement within the school board. Again, the graduate supervisor explained the process of assent to the students. All consent and assent forms were sealed and remained unopened until the end of the school year so that responses remained unknown, preventing any perceptions of favoritism or increased attention to those who provided consent and assent. As the phases advance, further permissions were not required as the course of the research

	took no radical turn.
If I publish or present my work, should I protect others with pseudonyms OR credit them by name?	I asked for both parents and students to decide and note on the permission their preferences regarding how they might wish to be referred to in the work. In the end, all students were referred to as 'Student' to protect anonymity, as many pseudonyms were not always appropriate for research.
Action and Social Justice	
Where is the 'action' in my research?	The action was in the iterative cycle of planning, acting and reflecting. This action was directed toward the designed experiences in which students engage, and my teaching and research practices
If I am trying a new teaching technique, what are its assumptions about learners, learning, and society?	This approach to teaching assumed that knowledge is created and lives.
Will my research aim to interpret the experience of students or others who differ from me in culture (including gender, race, class)?	Yes in that the students were younger and each student had their own unique lived experiences. In some cases, the students had different cultural backgrounds and some were of both genders.
How can I prepare myself to better 'read' their experience?	During analysis, my observations focused on all students. Having explored subjectivity in previous course work, I kept this in the forefront as I reviewed my observations, descriptions, and interpretations and considered how my subjectivity informed my interpretation.
If I publish or present my work, can I incorporate the voices of participants whose backgrounds differ from mine?	Work has not yet been published or presented.
Caring and Respect	
How will my research activities come across to students, parents, others? Will they feel interested, bored, honored, annoyed? (How can I find out?)	It is my belief that the work came across as interesting as it involved engaging participants as active agents in their own learning as they pursued questions relevant

	and interesting to them. They were given more responsibility for their own learning. Further, by way of parent-teacher interviews and ongoing conversations with parents, it is believed that the parents found the work interesting and that they supported the work of knowledge building with the participants outside of school. I was able to find out by way of conversation and observation.
Will the research be a learning experience for others, or just for me?	This learning experience affected my personal practice. It affected others as the work was shared with colleagues. It affected students in that it allowed many of them to see ideas as conceptual artifacts, knowledge as fluid and to further increase agency.
Can I involve my students (colleagues, parents, others) as my co-researchers?	In order to meet IRB protocol, I could not involve the students as my co-researchers. While I preferred to involve more colleagues as co-researchers, I realized that they had busy schedules and other priorities that would limit their ability to act as co-researchers.
If I publish or present my work, who might be hurt or embarrassed? Can I justify such damage by the public's right to know?	Mertler (2016) suggests educational research may be psychological harmful, including undue stress, embarrassment, retribution and the like. The risks associated with participating in this study were not greater than the normal risks of day-to-day life in the classroom.
Can the stakeholders read, understand, and critique my report? (Voice is an ethical as well as a rhetorical choice.)	It was and continues to be my intention to allow any stakeholder who might wish to do so access to the work.

Source: Questions quoted directly from Zeni (2009), p. 263-264.

Issues of Trustworthiness

Mertler (2009) explains, "(W)hen dealing with the validity of qualitative data, researchers are essentially concerned with the trustworthiness–for example, the accuracy and believability-of the data. Trustworthiness is established by examining the credibility and dependability of qualitative data" (p. 115). Credibility involves establishing that the results of qualitative research are credible or believable from the perspective of the participants in the research (Mertler, 2009). Dependability emphasizes the need for the researcher to account for the continually changing context within which research occurs (Mertler, 2009). The researcher is responsible for describing the changes that occur in the setting and how these changes affected the approach to the study (Mertler, 2009).

Accuracy, credibility and dependability in qualitative studies are also associated with rigor. Numerous methods or techniques helped provide evidence of rigor within the scope of educator-led action research studies. These techniques included repeating the cycle, prolonged engagement in the setting, experience with the action research process, triangulating evidence, member checking, and participant debriefing (Mertler, 2016).

Prolonged engagement and multiple cycles of action research resulted from the year-long timeframe. In the case of this research project, narrative analysis, observations and journaling will allow for the necessary triangulation. Further to this, member checking throughout the process with the purpose of ensuring that the participants and their ideas have been accurately represented (Mertler, 2009; Mertler, 2016) was be used. Finally, because this was a year-long action research study, prolonged engagement and persistent observation helped develop trust with the participants, helped me learn the culture of the setting and allowed for the observation of behaviours to the point it being routine (Mertler, 2009; Mertler, 2016). These approaches, used consistently throughout the research, increased the overall trustworthiness of the study.

Significance and Limitations

Several findings resulted from this action research. First, through this work, my own practice improved as I developed a better understanding of the role of the teacher in the knowledge building process. Second, students were provided with opportunities to engage with knowledge building principles in a computer supported collaborative learning environment, and, as a result, developed key characteristics of a learner in the knowledge age. Finally, this research had educational significance for other teachers and researchers as findings and reflections were shared with colleagues.

Limitations of the research begin with qualitative research itself. Bloomberg and Volpe (2012) explain “(b)ecause analysis ultimately rests with the thinking and choices of the researcher, qualitative studies are, in general, limited to researcher subjectivity” (Bloomburg & Volpe, p. 127). That is to say, the quality of the research is dependent on the individual skills of the researcher and can be more easily influenced by the researcher’s personal biases than quantitative research. Rigor is more difficult to maintain, assess, and demonstrate. As well, the researcher’s presence during evidence gathering, which is often unavoidable in qualitative research, can affect the subjects’ responses (Bloomburg & Volpe, 2012). In response, Alvesson and Skoldberg (2009) question the assumption that pure facts and data are the “solid bedrock of research” (p. 3) and suggest that qualitative research requires creative, open-minded approaches that acknowledge subjectivity.

Further limitations exist with action research as a methodology. Findings in one classroom may yield different results in different classrooms, contexts or languages (Baralt, Pennestri & Selvandin, 2011). In response to this critique, Mertler (2016) reminded us that with qualitative research, the goal is not to generalize to a larger population but to develop an in-depth description of a specific phenomenon in a particular setting. Further, while action research is not generalizable to large populations, it can be generalizable to relevant literature where similar or comparable contexts have been studied. And, there may be instances where action research solutions "will cross over from one setting to another; if that occurs, what we have is a wonderful by-product of action research" (Mertler, 2016. p. 255). However, generalizability can impede the efforts of school reform as school leaders may ignore the importance of context when looking at generalized findings (Mertler, 2016).

With action research, limitations also rest with bias. The school classroom is a complex setting. As a teacher researcher, full time days were spent in the classroom with the participants. Capturing everything by way of observations was, of course, impossible. When field notes were made in situ, they were often scribbled and in jot note form. Field notes were revisited later in the day to fill in missing detail. Often, observation notes were made after school, as time in school was spent supporting students. Reflections were completed on weekends. Admittedly, details were unintentionally omitted, partial or incomplete. This is the humility I bring to the research.

It is also important to note that, by spending the entire school year in the environment, key themes emerged. These themes emerged before the rigor of first cycle and second cycle coding. Suffice to say, when formal data analysis began, I, as the teacher-researcher entered into the data analysis with bias and pre-judgment. While I made attempts to review the relevant evidence with as much renunciation of *a priori* bias, I acknowledge these partialities. By way of engaging in the narrative of this action research, I have attempted to deconstruct my thinking.

In recognizing these limitations, the following measures were taken as per Bloomberg and Volpe (2012). The research agenda along with researcher assumptions were noted up front. A comprehensive description of the context was included. Coding schemes were scrutinized by advisors and through peer review. As the teacher-researcher, I worked toward creating an environment conducive to honest and open dialogue.

Scope and Delimitations

This study focused on one elementary school classroom with students in a grade three and four multi-aged setting from average socio-economic circumstances based on most currently available city statistics. It examined knowledge building as defined by Scardamalia and Bereiter (2003) and all principles associated with knowledge building. As the teacher-researcher, I engaged with the iterative process over the course of a school year, beginning in early October.

This study was delimited due to convenience sampling, and did not investigate any classroom outside of the convenience sample. Further, it was delimited to the time of one school year.

Summary

In sum, this chapter provided a detailed description of the study's research methodology and study design. A rationale for qualitative, and more specifically practitioner action research, was provided. Additionally, the context and research sample for the action research was detailed along with the methods of evidence collection and analysis as the acting phase of the research project. This analysis resulted in reflection and decision making for next steps in order to continually move forward for knowledge building. To navigate potential ethical concerns, a set of questions for self-reflection were asked and answered. Finally, issues of trustworthiness, especially pertaining to the credibility and reliability of qualitative research, have been addressed, as have limitations of the study.

Chapter 4

Findings

This chapter presents key findings from the evidence collected and analyzed throughout the year-long practitioner action research, including teacher observations, student artifacts, both digital and physical, and teacher reflections. Key findings that emerged include the following:

Finding 1: Students' Reconceptualized Knowledge and Learning

Finding 2: From Individual Toward Community Knowledge

Finding 3: Student Activity Selection Based on a Need to Understand

Finding 4: Students' Perception of the Purpose of the CSCL Tool Shifted over the School Year

Finding 5: Access to Technology Supported a Cultural Shift Toward Knowledge Building

This chapter provides a brief summary of the designs mentioned in the previous chapter, a timeline for the designs and analysis, followed by tables representing the findings from each analysis. The chapter then launches into a discussion about each of the key findings with examples of evidence captured to support each finding.

What happened?

As noted in the previous chapter, initial steps into knowledge building involved knowledge-building initiatives. Each of these four initiatives was considered an action research cycle and lasted from eight to twelve weeks. In brief, the designs for knowledge building involved the consistent use of a hook in an effort connect to student experiences and trigger student-generated questions. Designs early on provide students with opportunity to engage with content matter through video, audio, hands-on activities, field trips, and guest speakers, all in effort to get students “on sufficiently intimate terms with the object to be understood that they can ask some *why* questions with some meat” (Bereiter, 2002, p. 126). Designs further involved providing knowledge building scaffolds to students to support their face-to-face collaborative work and work contributed to GAFE. These scaffolds included ‘My theory is..’, ‘I need to understand…’, A better theory is…’, ‘This theory does not explain…’, and ‘Putting our knowledge together…’. Figure 4.1 below illustrates the time line of the year-long action research, including the subject areas, a the designs and the points of analysis throughout the year. Note that, while the timeline is presented linearly, students entered into each new knowledge building initiative with experiences from the previous initiative. Connections were made between content areas when and where possible. For example, students continued to look at plant growth as they studies light and shadow. Literary choices, for example, novel studies or nonfictional text, shared with the whole group or in smaller groups, connected to science or social studies topics. Math skills were applied when and where possible in other content areas. For example, students used measurement, addition, and subtraction throughout the plant topic of study. As well, students entered into each subject area design with knowledge building experiences from the other designs. It was in this way that each of the designs connected.

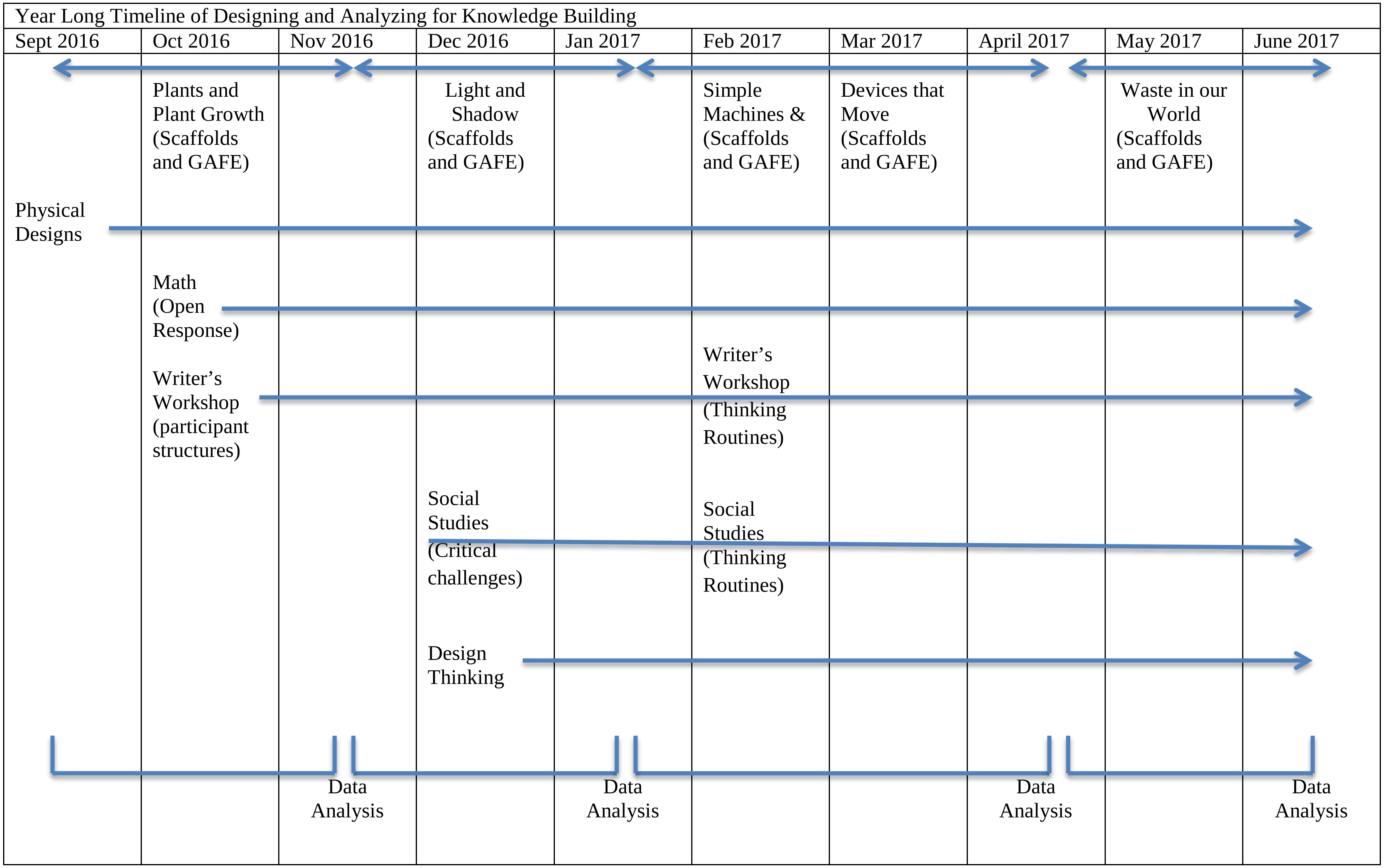


Figure 4.1: Timeline illustrating the knowledge building initiatives, concurrent work and data analysis over the academic year

Analysis of Evidence

As noted in the previous chapter, analysis of the evidence involved using codes for deeper reflection on the meaning of the evidence by assigning meaning to descriptive data compiled during the study (Miles et al. 2014). This evidence is consolidated in this chapter and trends are presented in tabular format. In hopes of establishing increased clarity and credibility, each table is preceded by the descriptors used and sample evidence captured under each code. The three tables below, with descriptors and sample evidence, include: 1) Summary of Instances of Knowledge Building Principles Found Across all Initiatives; 2) Summary of the Number of Times Scaffolds Were Used Across all Initiatives; and 3) Quality and frequency of scaffolded conversations in GAFE. A synthesis of the findings is presented in a discussion following all of the tables. From these tabular representations, further discussion of themes and specific examples of supporting evidence follows.

Analysis of knowledge building principles. Analysis began by using the knowledge building principles to code the evidence. Table 5 includes a description of each of the knowledge building principles. As well, a sample of the evidence captured is included for each knowledge building principle in hopes of providing insight into the process of coding the evidence.

Table 5

Knowledge Building Principles as Codes and Corresponding Sample Evidence

Knowledge Building Principle	Description	Sample of Evidence

Real ideas and authentic problems	Students are concerned with understanding, based on their real problems in the real world.	During a study on simple machines, a student asks, “My bike doesn’t work. I need to bring it to school to try to fix the gears.”
Improvable ideas	Students search for the best explanation rather than answer or the final state	T: How did you come to this idea? S: So, how I came to this idea it was the blue string wasn't working and the pulleys weren't cooperating so I'm like, alright, I need a different pulley. That's easy enough.
Idea diversity	Students generate a wealth of ideas	Students are provided with four numbers (9, 16, 25 and 43) and asked, which does not belong? Responses include: 43 because it is the only one bigger that 40 9 because it is a one digit number 16 because it is the only even number 25 because it is the only one that is a multiple of 5
Rise above	Students create higher level concepts (for example, by thinking “There’s got to be a better way!”)	First, we wanted it to be a boat but we figured out hat wouldn't work. The problem was that this is Styrofoam... we couldn't really get this thing floating. After that, we got this zip line idea. Well then, that didn't really work cuz you weren't really using stuff because it was supposed to be a straw and a balloon but there weren't any simple machines in it and then after that, we came up with this idea, with this (motions to a blow dryer attached to

		Styrofoam with wheels)
Epistemic agency	Students find their way in order to advance and take charge	Student: I need to understand if a plant can grow without dirt. Teacher: Can you design something that would help you understand? Student: I could put a sunflower seed in a cup of water and leave it by the window.
Community knowledge, collective responsibility	Community identifies shared progress and needed advances.	This student has made notes on chart paper rather than in her book. When asked why, she said she wants everyone to see the information.
Democratizing knowledge	All individuals are invited to contribute	Students stated “I think that we should have one place in the classroom where we can put all of our ‘experiences’ so that other kids can come and look at them”
Symmetric knowledge advancement	Expertise is distributed within and between communities and team members	Multiple student authors have shared the work in GAFE in creating a story where expertise was divided among students in regards to who is finding images for the story or writing words
Pervasive Knowledge building	Students recognize and use in and out of school and across contexts as opportunities	I went home and I did some more reading and now I want to change my idea. I thought that the museum should be named after the Sternburgs.
Constructive uses of authoritative sources	Students find and critically evaluate source material	“I looked on the internet and I found some information about the Blackfoot it was corroborated on another

		website."
Knowledge building discourse	Student discourse to share with each other, identify problems, and to improve the knowledge advancement in the classroom.	In response to the question, 'What is our next step as a community?' students suggest and agree to take apart things that we think have with gears in them to learn how they work.
Concurrent, embedded, and transformative assessment	Self and group assessment, feedback that enables advances	I asked them if they had any "I need to understand" in this case, the students had an I need to understand that asked primarily about how the Blackfoot set up their camps specifically why the tipis were set up in the circle.

In looking across all evidence collected, including observations, photos, audio and video recording and teacher reflections, Table 6 shows the number of instances of evidence of each knowledge building principle across all initiatives and concurrent work throughout the school year.

Table 6

Instances of Knowledge Building Principles Across Initiatives

Knowledge Building Principle	Initiative 1 (Plant and Plant Growth and concurrent work)	Initiative 2 (Light and Shadow and concurrent work)	Initiative 3 (Simple Machines and Devices that Move and concurrent work)	Initiative 4 (Waste in our World and concurrent work)
Real ideas and authentic problems	41	31	12	13
Improvable ideas	9	6	17	8
Idea diversity	36	14	24	10
Rise above	0	0	7	24
Epistemic agency	9	6	16	19
Community knowledge, collective responsibility	15	19	13	15
Democratizing knowledge	11	17	8	9
Symmetric knowledge advancement	9	15	14	11
Pervasive Knowledge building	6	2	4	0
Constructive uses of authoritative sources	0	1	2	1
Knowledge building discourse	1	0	6	7
Concurrent, embedded, and transformative assessment	2	3	6	6

Please note that this data is discussed in each of the subsequent findings below. In general, the evidence analyzed uncovered more instances of some knowledge building principles over others. While it might appear that some knowledge building principles became less evident as the year went on, it is also important to note that, in practice, students began working more collaboratively and contributions to knowledge building were made on behalf of the group as opposed to the individual. Further to this collaboration, note that the evidence for student engagement with three knowledge building principles, ‘Real ideas and authentic problems’ and ‘Idea diversity’ and ‘Pervasive Knowledge building’, tends to be higher in the first initiative than in subsequent initiatives. The higher frequency of student engagement with these three knowledge-building principles in the first initiative may be a result of students having had two opportunities to develop theories and search for new information in response to two different problems. Recall that students began using the scaffolds first with Post It® notes and then addressed a second problem with theory generation when the technology was introduced. Both attempts at knowledge building were accounted for in the data analysis for the first initiative.

Analysis of knowledge building scaffolds. This stage of the analysis involved looking at the frequency of the use of each knowledge-building scaffold in GAFE. Each scaffold supports the reification of the knowledge building principles and looking at the frequency of each of the scaffolds helped to further elucidate the state of the knowledge building in the classroom over time. Table 7 provides a sample of the evidence captured for each scaffold in an attempt to provide further clarity into the analysis. Note that the use of the scaffolds was not mandatory and evidence captured without the scaffold was included with the corresponding scaffold. Examples of this are also provided in the table below.

Table 7

Knowledge Building Scaffolds and Samples of Evidence Capture

Scaffold	Sample of Evidence Capture
My theory is…	In response to why some plants grow faster than others: "My theory is that some seeds form faster than others (its something genetetical) (sic) and they get a head start."
I need to understand…	I need to understand if a book is a simple machine.
	How can someone get up something steep and bumpy?
New information…	'Did you know that the handle of a pizza cutter is a lever?'
	New information is that plants are all around the world and different shapes and sizes.
A better theory is…	"A better theory is that if you put a seed in fresh packed soil and feed it with water and put it in a sunny spot it will grow"
This theory does not explain…	No evidence captured
Putting our knowledge together…	No evidence captured

The lack of evidence for the two scaffolds 'This theory does not explain' and 'Putting our knowledge together' resulted despite having a research process in place that worked for the other scaffolds. These scaffolds were not used in GAFE by the students. Table 8 provides the frequency for each of the knowledge building scaffolds used over time in GAFE. Recall that technology was unavailable early in the school year due to start up issues. Therefore, students first experiences with the scaffolds were with Post It® notes. The analysis of the use if the scaffolds includes both the contributions by way of Post It® notes and GAFE for the first initiative.

Table 8

Summary of the Number of Times Scaffolds Were Used Across all Initiatives

Scaffold	Plants and Plant Growth (Post It® Notes)	Plants and Plant Growth (GAFE)	Light and Shadow (GAFE)	Simple Machines and Building Devices (GAFE)	Waste in our World (GAFE)
My theory is…	19	15	14	8	8
I need to understand…	21	20	31	12	13
New information…	16	33	21	21	29
A better theory is…	9	5	4	4	0
This theory does not explain…	0	0	0	0	0
Putting our knowledge together…	0	0	0	0	0

As each scaffold supports the reification of the knowledge building principles, this table helps to further elucidate the areas of strength in the knowledge building community. As with the previous table, this analysis is discussed in further detail within the findings below. Here, however, it is important to note that the evidence highlights that certain scaffolds were used more frequently in GAFE over others. In looking back over observations and reflections, I can say that, in working toward creating a knowledge building community, more emphasis, modeling, explanation and focus was placed on the use of 'My theory is…', 'I need to understand…' and 'New information…' as opposed to the remaining three scaffolds of 'A better theory is…', 'This theory does not explain…' and 'Putting our knowledge together…' This is discussed in more detail in the findings below.

Analysis of the quality of scaffolded discourse in GAFE. This stage of the analysis involved looking at the quality of the scaffolded discourse in GAFE. As previously noted, the codes used were based on the work of Fu et al. (2013). These descriptors were chosen by Fu et al. (2013) in attempt to understand how an idea improved in knowledge building discourse over time. Table 9 provides a description of each code and a sample of the evidence captured for each code in an attempt to provide further clarity into the analysis.

Table 9

Description of Codes used in Examining Quality and Frequency of Scaffolded Conversations in GAFE and Sample of Evidence Capture

Codes based on Fu et al. (2013)	Description of Code	Sample of Evidence Capture
Chit Chat	brief messages, emoticons, greetings that are not connected to the use of the	'who wants to comment me?' 'hi'

	scaffolds	'I'll come back later' ☺
Idea Sharing	sharing of information, facts including images, videos or links to websites relevant to the seed question	all you need to know about levers: (link provided to a website with video and text to speech) http://www.pkphysicalscience.com/article/433/1/what-is-a-leverlogin?username=thealberta&password=library
Idea Co-Construction	questions or attempts to engage conversation that are relevant to the seed question	In response to a Waste in our World problem, a student posts 'but there is a problem. and the problem is that I see a lot of flies in the yellow bin. So how do we remove them?'
Idea Development	at least one explanation event and the explanation event must not directly build on the seed question but rather develop beyond the seed as moving the idea progressively forward	No evidence captured

Recall that these descriptors of discourse correspond to different theoretical perspectives and are not developmental (van Aalst, 2009). In CSCL, different forms of discourse are used at different times for different purposes (van Aalst, 2009; Garrison, 2011). Note that, while the research processes were in place to collect evidence for idea development, there was no evidence captured from GAFE. From here, Table 10 provides a summary of the quality and frequency of scaffolded conversation in GAFE over the course of the school year and all knowledge building initiatives.

Table 10

Quality and frequency of scaffolded conversations in GAFE

Descriptors based on Fu et al. (2013)	Plant & Plant Growth	Light & Shadow	Simple Machine & Building Devices	Waste in our World
Chit Chat	4	6	20	51
Idea Sharing	2	1	21	29
Idea Co-Construction	0	0	3	16
Idea Development	0	0	0	0

Table 10 shows a progression over time as students added to the quantity and variety of the scaffolded discourse. The student contributions coded as idea co-construction consisted mainly of events involving student questioning. In these instances, answers were usually not provided by other students. However, in asking questions, some of the students demonstrated a shift in contribution patterns. Further, while students did not appear to contribute to idea development on GAFE, there was an increase in the overall number and the variety of contributions made.

Recall that, in designing for student knowledge building in the third initiative, I took on the responsibility of creating and sharing documents to all students, thus resulting in 8 documents shared by all, in an attempt to bring the community together to a more common digital space. My action was opposed to earlier initiatives, whereby most students created their own document and shared with a few selected peers. My redesign might account for the increased number of contributions as students had a common place to comment on each of the simple machines as opposed to many places created by various peers and shared only with a few.

Furthermore, in the fourth initiative, Waste in our World, many students organized into groups based on identified problems of interest and then proceeded to create Google documents, as a group as opposed to individually, to support idea sharing and co-construction. Again, this resulted in fewer documents for students which other students were asked to make contributions. It might also be that the problems were more authentic to the students as they had seen the evidence of waste in their immediate environment and, thus, some students may have had more contributions or may have been more motivated to make contributions because it was a meaningful problem.

However, it might also be the case that, in both of the initiatives noted above, given the time spent over the first part of the year on improving ideas and identifying needs for understanding in face-to-face interactions in the classroom, some students might have felt safer in contributing to the online environment. That is to say, these increased contributions over time might have also been due to growing trust among peers.

While evidence collection processes were in place for idea development, a lack of evidence existed for this descriptor. It might be that designs for knowledge building did not support idea development among students either because the designs were insufficient or perhaps because idea development in GAFE might have been a step too far for participants at this point.

These descriptive coding procedures were important as they highlighted changes in student application of knowledge building principles, use of scaffolds and scaffolded conversation that appeared to occur over the year within the community. However, as the teacher-researcher, I felt that a necessary next step was to delve more deeply into why and how things happened as opposed to stopping at a partial understanding by focusing solely on the frequency of what happened.

Consequently, I returned to the Social Infrastructures Framework (Bielaczyc, 2006). The framework was used in the analysis of the evidence collected across the year to better elucidate not just what happened in the classroom, but why it might have happened.

Analysis of evidence using the Social Infrastructure Framework dimensions and sub-dimensions. While the data analysis to this point provides some insight into what was happening, specifically in regards to the scaffolds for knowledge building, the scaffolded discussions on GAFE, and the knowledge building principles themselves, a deeper understanding of why or how we got there is necessary.

The next stage of analysis entailed multiple passes through the data sources for various dimensions of the Social Infrastructure Framework and the 14 sub-dimensions that provided further insight into in each of the four dimensions. Data was coded into categories corresponding to the design dimensions. Table 11 below shows the results of the coding across all data. The summary of the Social Infrastructure Framework and example questions used to support data analysis is provided in Appendix C.

Table 11

Analysis of Evidence using the Social Infrastructure Framework Dimensions and Sub-Dimensions (Bielaczyc, 2006, 2013)

Dimension	Sub-Dimension	Instances Across all Initiatives
Cultural Beliefs Dimension	Conceptualizations of learning and knowledge	71
	Student Social Identity	58
	Teacher Social Identity	7
	Purpose of Tool	29

Practices Dimension	Activities	69
	Associated participant structures of students	28
	Associated participant structures of teachers	25
Socio-technico-spatial Relations Dimension	Student–teacher–machine–physical-space configurations	1
	Student–teacher–cyberspace configurations	18
	Cyberspace–physical-space relations	3
Interaction with the 'outside world' Dimension	Bringing in knowledge from the outside	9
	Extending the audience for student work	2
	Interacting with others	5

Reviewing the data collected and analyzed with the four dimensions of the Social Infrastructures Framework - cultural beliefs dimension, practices dimension, socio-technico-spatial relations and interactions with the outside world dimensions - helped to elucidate the successes in the implementation of knowledge building over the course of the year. Earlier findings presented in the previous tables pertaining to the knowledge building principles, knowledge building scaffolds and the discourse in GAFE are consolidated into the findings presented and discussed in the following section.

Finding 1: Students' Reconceptualization of Knowledge and Learning

As the year progressed, evidence gathered from this action research suggested that for some students, conceptions of knowledge and learning began to shift. Specifically, the evidence suggested that early on in the year, some students saw knowledge as external, stable and objectively real; some students saw learning as the internalization of the external (Davis et al. 2015). Conceptualizations shifted for some, as there were students who began to see learning as an ongoing process of revising thoughts and knowledge as unavoidably partial, biased and distributed among humans (Davis et al. 2015). Evidence collected over the year and presented below helps to elucidate this shift.

When considering which knowledge building principles might reflect student conceptions of knowledge and learning, evidence of improvable ideas is relevant in that this principle requires students to move beyond a concept of learning as ‘being done.’ Scaffolds connected to this principle include new information, a better theory, and putting our knowledge together.

Knowledge building scaffolds were introduced to and modeled for the students by me, as the teacher, across all initiatives, both verbally and in writing. Referring back to Table 8, evidence collected and analyzed uncovered ongoing student use of the scaffold ‘New information’ across all initiatives. What might be interesting to note is that some students worked more independently at the beginning of the year and the contributions of new information often represented individual contributions. Toward the third and fourth initiatives, some students were working more in groups, as noted by teacher observations and contributions to GAFE. Contributions were sometimes made as a group rather as individuals, resulting in fewer contributions. Examples of this are noted in further detail in the next finding.

Regarding the use of scaffolds to support the reification of the knowledge building principle of idea improvement, Table 8 shows no evidence of idea improvement in GAFE as the scaffolds ‘A better theory…’, ‘This theory does not explain…’ and ‘Putting our knowledge together…’ had not been used. Regarding scaffolded discourse in GAFE, Table 10 shows increasing instances of idea sharing over the course of the school year, resulting in limited idea diversity in the first two initiatives but more diversity in the latter part of the year. The evidence analyzed early in the school year showed that most contributions to scaffolded discourse in GAFE consisted of chit-chat.

Recall from the literature review that each form of discourse –chit-chat, idea sharing, idea co-construction and idea-development- are used at different times for different purposes (van Aalst, 2009). It might be that the chit-chat was contibuted as some students began to create what Garrison (2011) termed social presence. More specifically, the chit-chat may have supported some students to identify with one another, to further develop personal and affective relationships by allowing some students to project their individual personalities, and to create a trusting environment (Garrison, 2011).

Overall, data collected, analyzed and displayed in Table 10 shows no evidence of idea development from the data collected and analyzed, which has been identified by Fu et al. (2013) as discourse necessary for moving an idea forward for knowledge building. Recall the data analysis displayed in Table 6 showed incidents idea improvement as the year progressed, especially in the areas of design thinking and writer's workshop.

Supporting these analyses across all tabular representations is Table 11, which displays the findings from the analysis of Evidence using the Social Infrastructure Framework Dimensions and Sub-Dimensions. This analysis provided evidence that, among all dimensions and sub-dimensions of the framework, the greatest number of instances of evidence was found in relation to conceptualizations of knowledge and learning. The following examples of observations and reflections were pulled from all evidence across all initiatives in hopes of providing increased clarity and understanding of the data presented in the each of the tables regarding some of the students' reconceptualization of knowledge and learning over the year.

Noted in an early teacher observation, the following evidence suggests how a particular student saw knowledge as something to accumulate and learning as something to be done.

> *I passed out the activity called 'Vocabulary Knowledge Rating' to the students and explained that each student was meant to rate themselves based on how well they thought hey understood each concept on a scale of 1 to 4. When I read the words out loud from the sheet of paper, one student suggested that he didn't learn anything in school and that he knew all the words already. He said that he was a four for all of the words (Meaning that he knew them all well enough to teach others). He elaborated by stating that his mom buys him a book at the beginning of the summer called grade 4 learning. He stated, "I do the book all summer and so now I know everything about grade 4." (Teacher Observation, October 15, 2016)*

This student argued that he had finished learning by way of finishing the workbook. It appeared that he regarded knowledge as standardized in that it is connected with grade level outcomes. Based on his comments, he argued that because he had finished the workbook, he knew all about grade four and had nothing left to learn.

Further, early on in the school year, comments made by some students seemed to suggest that, at times, they perceived work as something to be 'done' or completed, even when given tasks with opportunity for multiple responses. For example, students were asked to look for new information about plants. They were given time and access to digital and non-digital resources to do so. One student approached me and stated:

> *Student: "What do we do when we are done?"*

Teacher: "You are looking for new information about plants to add to the board."

Student: "I did. I added a sticky note. I'm done."

Based on this comment, it is possible that this student sees learning as an accumulation of facts; she added her fact to the board and considered herself finished. Further to this example and still early on in the year, in another conversation, a different student asked:

Student: "What can I do now?"

Teacher: "Why don't you look at your science theory and think about next steps."

Student: "I'm done…"

Teacher: "What do you mean when you say 'I'm done?'"

Student: "I finished"

Teacher: "Finished your theory?"

Student: "Yes"

Again, this student may have held a conception of learning and knowledge as something to finish or acquire rather than a process of continual improvement.

Each day in math, students were presented with an open-ended math question, where many solutions were possible. A task was presented one day as, "25 is the answer. What is the question?" and students are asked to think of multiple solutions. A student shared his notebook with me, with '20+5' written down and stated, *'I'm done.'* By providing one answer where many are possible might suggest that he does not yet see opportunity for idea diversity. It is plausible that, at this point, he considered one idea as sufficient. It might also be that the initial problem did not meet the criteria needed to be a real problem for the student in that it might not have been meaningful to the student.

Shifts in some student conceptions of learning and knowledge were evident soon after introducing the knowledge building scaffolds. When students were asked to consider the differences in plant growth among the student samples, the following dialogue was captured as evidence.

Teacher: "Why do some plants grow faster than others?"

Student 1: I think I had a bad seed and that is why it did not grow.

Student 2: How you know it was the seed?

Teacher: We need to think about…(interrupted)

Student 2: …(interrupting) I'm questioning the theory!

This comment about questioning the theory suggested that this student might have started to see his role change from one who accepts information to one who has opportunity to question what has been said. Coincidently, this was the same student who had completed the 'grade four workbook' over the summer and who had argued that, in finishing the workbook, he had learned all he needed to know.

Further work with knowledge building principles and supporting scaffolds, along with whole class conversations around building theories and improving ideas over time, resulted in increased evidence of idea improvement for some members of the classroom, perhaps signifying a further shift in their conceptions of learning and knowledge. Specifically, for some students, learning became more about generating theories and improving ideas rather than being 'done.' While this shift happened earlier for some students, in and around the second knowledge building initiative, the shift was noted for more students in the third initiative in the later part of the academic year. In looking over the analysis of the evidence, Table 6 shows that, when using knowledge building principles as codes, the greatest number of instances of idea improvement and idea diversity, knowledge-building principles aligned with this shift in the conceptions of learning and knowledge, was noted during the third knowledge building initiative. Additionally, Table 6 reveals that rise also above became evident in the third initiative and increased into the fourth initiative. Recall that it was in these initiatives, specifically Building Vehicles and Devices that Move, and then onto Waste in our World, that students had increased number of opportunities for design thinking in response to student-identified problems. Further discussion regarding student-identified problems follows in subsequent findings.

In looking back to Table 10, the evidence collected regarding the quality of scaffolded conversations shows an increase frequency of idea sharing over the third and fourth initiatives as opposed to earlier initiatives. This idea sharing specifically occurred in the form of sharing images and links to video connected to the identified problems. Again, this evidence supports the suggestion that some students were beginning to shift their conceptions of learning. As opposed to finding a single piece of information and considering themselves done, as was the case with a previously mentioned student, more students in the class seemed to demonstrate commitment to finding and reporting new ideas to discourse in GAFE. Please note that the specific evidence collected regarding scaffolded discourse in GAFE is explored in greater depth in a subsequent finding regarding the use of the tool itself. At this point, the evidence collected highlights a shift in learning being done toward learning as ongoing.

In the third cycle, concurrent work in social studies highlighted a shift in conceptions of learning for some students. Students were sharing some work they had done regarding the Blackfoot Nation and were prompted in class discussions with the knowledge building scaffolds. For example, I asked the class if they had any "I need to understands…" for the presenter. In this case, a few students identified a need to understand how the Blackfoot set up their camps and specifically why the tipis were set up in the circle. As we were discussing as a group, some students generated some ideas, using the scaffold 'My theory is.' For example, one student remarked, *'My theory is so that they can share a fire in the middle.'* When the students finished sharing, the presenter of the original work looked at me and asked, *"Are we done because I need to write all these questions down before I forget them so I can look at them and bring back more information the next time we have social studies."* This comment from the student suggested that, in this instance, he might have seen knowledge as evolving or perhaps intentionally constructed. Coincidently, earlier in the year, when I had asked the class, *"Is anyone's work perfect right now?"* this same student replied, *"Some people's work maybe perfect…"* suggesting that, earlier, he might have considered ideas as something to be finished and unimprovable.

At a similar point in time, another student presented on the First Nations and the uses of the various parts of the buffalo. When she shared her information with the class, I asked the other students if they had any 'I need to understand…' questions for the presenter. Some of the students put their hand and asked:

"I need to understand what they used the blood for."

"I need to understand how they used bones as tools."

"I need to understand what they use the buffalo's eyes for."

Interestingly, one student informed the class, *‘I know that the First Nations did not use the eyes for anything.’* When I asked him why he thought that, he said, ‘*When I looked at the diagram in the textbook, there was nothing written down beside the eyes, but all the other parts had something beside them’* meaning that textbook provided explanation for other parts of the buffalo. This comment suggested that this student saw knowledge as simple and concrete; the textbook, seen as an authoritative source, did not provide the information, so it must not exist.

Following the discussion and the identified needs for understandings among the group, the student-presenter returned to the Internet and the textbook. She found an image of the bone made into a tool that she printed and pasted onto her second sheet of chart paper. Not having much luck with the other needs for understanding, she turned to email and contacted an outside source to receive the pertinent information:

------*Original Message*-----
From: Parker, Robin J
To: (Recipient)
Subject: Question about the buffalo from a student in Calgary

Dear (Recipient),
My name is (Student). I am emailing you from my teacher's email. I am learning about First Nations who lived in the grassland region of Alberta.

I am learning about buffalo. I looked at our textbook, the internet and your website. They said they use every thing from the buffalo but they did not tell us about what did they used the eyes and blood for. I hope you can help me. Do you know what the First Nations used the eyes and the blood for?
thanks!
(Student)

The response followed:

From: (Recipient)
Sent: Tuesday, April 25, 2017 9:48 AM
To: Parker, Robin J.

Subject: RE: Question from a student in Calgary

Hello (Student),

First off we always like to clarify that everything had a use... not everything was used every time and all the time. If everything was always used we wouldn't have over 10 meters deep deposits of bones left over from the buffalo jump days here at Head-Smashed-In! It is a common misconception.

Now on to your questions - yes I do know what the eyes and blood were used for!

The blood was used as food. It could be drank fresh or cooked with. It is full of good nutrients.

The eyes had a very special use! They could be used (along with brains) to tan hides. Or they could be rubbed onto the outside of the par fleche containers that held pemmican as an insect deterrent... to help the pemmican to last even longer.

I hope that answers your questions.

Have a great afternoon.
(Recipient)

Figure 4.2. Example of student effort to contribute to community knowledge

After receiving the response, the student-presenter shared the information with her fellow students, who then identified more needs for understanding about the par fleche and what it meant to tan the hides. This student continued her work to build further understanding.

Further evidence of shifting perceptions of knowledge and learning came from teacher observations later in the year. For example, evidence collected over the year suggested that the use of open-ended questions in math did allow for some students to understand that math can be a more creative pursuit than they might have previously thought. For example, ongoing observation of student contributions, both verbal and written, showed increasing evidence of diversity in that many students were increasing the number of responses to the open-ended question posed each day in math. This increase suggested that more students began to see opportunity for diversity of ideas as opposed to single solutions.

In science, students were asked to complete the Knowledge Rating activity (see Appendix C) for a new topic of study. Students were asked to rate their understanding of different vocabulary associated with the topic of study as a way of introducing the topic. They had done this activity once before in a different topic. The following teacher observation came from this activity.

> *A student explained to the class that the last time she did this activity, her rating for one of the words decreased after the unit of study, specifically the word 'sun' because she realized there was so much to know about the sun and throughout the topic, she realized she didn't know as much as she thought she did. (Teacher Observation, February 8, 2016)*

In changing her rating after the unit of study to demonstrate that her understanding was not as complete as she thought it was might suggest that she was beginning to see knowledge as evolving rather than an accumulation of facts. However, it might also suggest that she saw knowledge as a larger accumulation of facts than she had assumed.

Further examples of possible shifts among the students' conceptions of knowledge and learning come from student contributions to GAFE. Figure 4.3 represents an early contribution in the form of theory generation, where one scaffold had been used. In this example, note that the student created a theory. Note also that Figure 4.3 below represents the full contribution by this student. That is to say, this student contributed a theory; no further contributions were made that demonstrated idea improvement. It might have been that this student did not see an opportunity for idea improvement. It might have also been due to other factors, including, but not limited to, this student being relatively new at this point to knowledge building, or perhaps this student was working with a problem that was not authentic or meaningful.

Why do some plants grow faster then others.

My thery is that some seeds form faster than others (its something genetetical) and they get a headstart!

Figure 4.3. Early theory generation.

Over the course of the year, some students demonstrated a willingness to commit to idea improvement in GAFE, again suggesting that knowledge may have been seen by some students as something that evolves rather than as a fixed set of facts. Figure 4.4 represents early attempts to improve an idea. In this example, two scaffolds have been used. This student is improving on her own theory by adding more descriptive detail, which meets the one of the criteria for idea improvement set forth by Bereiter (2016). She has also added a theory but did not marked it as such when she addressed the timing of the planting. Scardamalia (2004) explained that students may use scaffolds but are not required to do so, emphasizing that theirs is a principled approach rather than a programmed one.

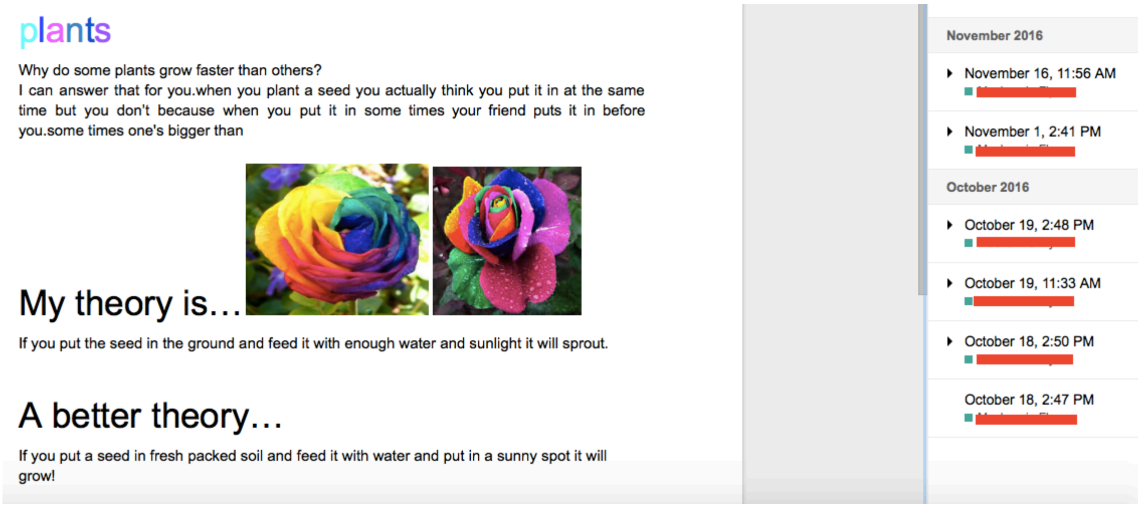


Figure 4.4. Idea improvement in GAFE

Figure 4.5 represents a student improving ideas when engaged in design thinking. This student realized, after testing, that the design was inefficient. She noted, *"The basket keeps falling off when I try to move it… I need to fix it."* She returned to redesign, demonstrating idea improvement, without prompting from anyone.

Figure 4.5. Evidence of idea improvement

Similarly, a small group of students was involved in designing a solution to the amount of garbage the school generated over the year. In particular, the students noticed that a number of potato chip bags and granola bar wrappers were a major source of garbage in the school. These students generated a theory, in the form of a design plan, that old snack wrappers could be up-cycled into jewelry; this design involved creating a school club where students from other classes could join and make jewelry from recycled material. Figure 4.6 is an example of the contribution this group made to GAFE to share their design to their peers.

Figure 4.6. Student design for reducing school waste

The students working with this design created a prototype and realized that the process was not working as they planned. They identify that they need to better understand the process. In finding new information and generating a better theory for how to make their jewelry, they realized that they did not have access to the appropriate supplies at school. They stated, “We are done for now.” The use of this phrase ‘for now’, as opposed to simply stating ‘I’m done’, implied that these students potentially saw that opportunity existed to gain further understanding and to continue to improve the idea; they were limited, in part, by a lack of supplies rather than their concept of knowledge and learning.

In a social studies task, students were asked to explore the significance of Alberta's fossil heritage and the Royal Tyrell Museum by considering whether the Museum was appropriately named after Joseph Tyrell. The following conversation was captured as evidence of idea improvement.

> *S: I went home and I did some more reading and now I want to change my idea. I thought that the museum should be named after the Sternburgs.*
>
> *T: What were your criteria?*
>
> *S: It should be named after someone who was brave, loyal and honest. But when I read more at home about Tyrrell, I thought he was braver than the Sternburgs because he was the first one to travel to Alberta. He was an adventurer. So I changed my mind and I think it was a good choice to be named after Tyrrell.*

This evidence suggests that this student saw an opportunity for idea improvement rather than completed work; she also demonstrated pervasive knowledge building in the way she continued to consider and investigate beyond the walls of the classroom.

In earlier design thinking tasks, I reflected on the process, specifically how difficult it can be for students to improve their ideas.

> *As they (PD day guest speakers) are talking about design thinking and as I've done design thinking in my own classroom, I see the connection (with KB) around the continual improvement of ideas. I see also that this is a piece of the work where my students really struggle in that they have a hard time accepting feedback from others. They have a hard time improving their work based on the feedback of others and so this was on my mind going into the session today. (Teacher Reflection, February 3, 2017)*

However, with this third initiative, there was an increase in the evidence of improvement of ideas, specifically students who were willing to engage in the iterative process.

Recall that it was during this initiative that students engaged in ongoing design work in the Maker Space. Students were asked to design in a simple machine in response to an identified problem. While working with the materials in the Maker Space, idea improvement became most evident when physical designs were not working and needed to be redesigned in response. For example, one student was working with pulleys and when the stings kept falling off, she continued to work on improving the design by using different pulleys, different string and different supporting structures over several iterations as shown in Figure 4.7 below.

Figure 4.7. Idea Improvement in the Maker Space

As the teacher, I would contend, based on a collection of reflections, that I, too, experienced a shift in my own conceptions of knowledge and learning. Recall that Kemmis et al., (2014) define practice as

> a socially established cooperative human activity in which characteristic arrangements of actions and activities (doings) are comprehensible in terms of arrangements of relevant ideas in characteristic discourses (sayings), and when the people and objects involved are distributed in characteristic arrangements of relationships (relatings), and when this complex of sayings, doings and relatings 'hangs together' in a distinctive human social project. (p. 50)

Regarding my own practice, I came to see how it is that I contribute to cultivating a culture where student work is finished as opposed to improved, especially in regards to sayings or discourse, as noted in the teacher reflection below.

> *I realized today, as I was giving directions to the students, that I emphasized that a task needed to be done...something like, 'okay, everyone, let's get this done and handed in…' I heard myself saying the words and realized that it was just earlier in the day that I was explaining to the students how work can be improved over done and now here I was, asking for something else to be done. It also made me think about a conversation I had earlier in the week with a teacher who had a folder of work, one side marked as done and the other as not done. Students in my class also reported that in the past, they would get to use technology if they were done their work, as a reward or something to fill in time. This really made me start to consider how often we emphasize being done work. In some cases, the only time we allow opportunity to improve work is directly connected to editing during the writing process, or when a student finishes work early and we send them back to add more detail because we don't have any more work for them to complete. It also made me think back to a comment earlier in the year, when a*

student said that she didn't like to work in groups. She explained that there was usually too much fooling around and then she felt bad about herself when she didn't get her work done. Again, as we push to get work done, what messages about learning are we giving students? This student sees success as completion rather than improvement. (Teacher reflection, January 29, 2017)

Although I entered into the research with an understanding of knowledge building as the continual improvement of ideas, years spent in the classroom have led to sayings and discourse that require potentially work in opposition to knowledge building efforts. While I was designing to engage students in knowledge building, my practice, specifically in this case, my sayings or discourse, were arguably not always supporting the efforts toward knowledge building. At this point, I became more aware of my sayings and how language might best support the work of knowledge building. I attempted to become more intentional in explaining how things were done 'for now' but attempted to highlight possible next steps should time allow. This also reaffirmed the importance of making as make cross curricular connections to, again, intentionally highlight to students that opportunities exist to continually build knowledge even though we have 'moved on' to a new curricular topic. This reflection, in brief, is an important observation of my own pervasive knowledge building as I continue to improve my own ideas of what constitutes practice.

In sum, evidence suggested that early on in the year, many students saw knowledge as external, stable and objectively real. For example, some students would refer to 'being done' work instead of pursing further opportunities for idea improvement or diversity. Conceptualizations began to shift as some students began to potentially see learning as an ongoing process of revising thoughts and knowledge. While students might have continued to internalize the external by way of taking in new information either from me, as the teacher, each other, or from other sources, they worked beyond simply internalizing toward continuing to identify what they needed to understand based new information and improving ideas.

Finding 2: From Individual Toward Community Knowledge

The students entered into this classroom with bias: prejudgments about their world based on perceptions, actions and interpretations that are conditioned by prior experiences (Davis et al., 2015). These biases included, but were not limited to, what classroom work should look like, their role in the classroom, the role of the teacher, how they view each other and the role of technology. For example, students remarked that they had used technology in the past when they were done their work. As well, despite ongoing opportunities to converse with and provide feedback to peers, students consistently wanted to share their connections, questions and inferences with me as the classroom teacher, suggesting the importance of teacher approval to these students. Further, one student noted that she wanted to sit in rows *'because that's how they do it on TV.'* According to Davis et al. (2015), these biases can open the door for dangerous attitudes – believing that enough is known or not putting forward effort to make sense of other worldviews.

Recall that the knowledge building principles defined by Scardamalia (2002) include real ideas and authentic problems, improvable ideas, idea diversity, rise above, epistemic agency, community knowledge and collective responsibility, democratizing knowledge, symmetric knowledge advancement, pervasive knowledge building, constructive use of authoritative sources, knowledge building discourse and concurrent, embedded and transformative assessment. The evidence collected and analyzed would suggest that, by engaging with these principles, and the associated scaffolds, a shift occurred in the perceptions held by some students regarding their social identity, as they became encultured into the world of knowledge building. Evidence would suggest that some students began to think of classroom roles differently, especially how students viewed their purpose in the learning environment and how students view each other, either as a learning resources, as team members, or as competitors.

When considering student social identity, and specifically moving from the individual to the community knowledge as this finding suggests, certain knowledge building principles come to mind, including: community knowledge and collective responsibility, symmetric knowledge advancement and democratizing knowledge. These are each discussed in turn.

Table 6 shows instances of community knowledge across all knowledge building initiatives. Toward the third and fourth initiatives, evidence that traced instances of contributions to community knowledge decreased. However, one possibility is that this decrease might be accounted for in that students worked more collaboratively during the third and fourth initiatives, especially when engaged in design thinking tasks. Contributions were made with more frequency as a group as opposed to an individual. Figure 4.8 shows an example of a group contribution in response to an identified problem with recycling at the school. This group of two had designed, as a solution, a ‘Green Team.’ One document was created, with one design idea, and with both students contributing.

People don't care where the garbage,recyclables,refundable and organics go maybe some people do like us. So we want to start a Green Team the team will be made of who ever knows where everything goes. They will make sure that we recycle as a school!

Figure 4.8. Group contribution to GAFE

The following example in Figure 4.9 also shows a group working on a single document, where seven students are contributing to the design. In this design, the students developed a sort of advertising campaign for the school to raise awareness for up-cycling.

Figure 4.9. Group contributions to GAFE

The examples in both Figure 4.8 and 4.9 were each coded as one contribution to GAFE, despite having multiple students working on the design and contributing to the contribution. This process of data analysis might account for the decrease in instances of community knowledge in later initiatives.

A specific scaffold used in GAFE to support community knowledge was 'Putting out knowledge together.' Table 8 shows that no evidence was collected demonstrating the use of this scaffold. Regarding scaffolded discourse, Table 10 shows there was some evidence toward the end of the year of idea co-construction, mainly by way of asking questions. Table 10 further shows that there was no evidence of idea development within GAFE. This evidence suggests that community knowledge was more evident in the face-to-face community than the networked community. For example, Table 11, which displays the results of the analysis of the data using the Social Infrastructure Framework, reveals evidence existed in relation to student identity. Recall from the literature review that student social identity refers to how students see themselves and their peers as either competitors or resources for one another (Bielaczyc, 2006, 2013). The evidence below, pulled from observations and reflections, highlights how students moved from working individually towards working as resources for the community in the face-to-face community.

During the course of the school year, evidence indicates that some students began to shift toward participant structures that fostered interactions for knowledge building. Early on, multiple students consistently asked to work alone and to sit in rows rather than groups. When asked why, responses were either connected to social reasons, emotional reasons, cultural reasons or challenges around shared responsibility. The following examples of the responses, collected from a range of students, are as follows.

Social: *I don't get along; When people talk too much I get distracted; (Student) wandered off reading a book and said he "doesn't want to be in the group."*

Emotional: *I feel left out; I fool around when I'm in a group and I don't get my work done so then I feel bad about myself; It's noisy and I get frustrated and mad at myself; People are too annoying they don't do anything they don't pay attention and they are rude; I can relax when I'm on my own with no one talking;*

Cultural: *On TV, kids in school sit in rows when they go to school.*

Shared Responsibility: *No one tells you what to do when you work alone; When you work alone you can do what you want; When you work with other people you have to change what you want to do; You can do your own ideas and not what others say when you work alone; There's only one electronic and only one person gets to type; Nobody gets to do their idea; When I work with other people they boss me around; It lets my ideas flow out without blocking them when I work alone; I don't get anything finished, people in my group don't get anything finished and they say it's my fault; I got kicked out and couldn't do anything; I don't like partners because I'm trying to focus and one person does all the work*

Early on, intentional conversations in classroom revolved around the advantages of working in a community and the concept of epistemic agency. Students began to take on the work of making their knowledge public in their own ways. These actions might suggest that student social identity was beginning to shift; students were beginning to see themselves as resources for others as opposed to competitors.

Symmetric knowledge advancement, where expertise was distributed within and between communities and team members, was especially evident in the social studies topics where students reported findings and were required to return to the group with idea improvement, particularly in adding detail. Recall the students discussed earlier and their social studies presentations. As they asked for students to share their needs in regards to understanding, and their subsequent commitment to finding more information, they saw themselves as resources for others. For example, when the previously mentioned student asked, *"Are we done because I need to write all these questions down before I forget them so I can look at them and bring back more information the next time we have social studies?"* suggested that he saw knowledge as evolving and that he saw his role in the community as an important one in helping the knowledge advance. Similarly, when the student went on to research more about the par fleche and the buffalo hides, her actions and the follow-through on the requests from her peers may suggest that she saw herself as resource for others as she continued the search and add to community knowledge.

Further to this, in the study on plants, a student took notes directly from a book but she copied them onto a chart paper. This book was one of several that I had signed out from the public library and made available as authoritative sources. As we had not yet discussed authoritative sources as a group, this student was likely not questioning the authority of the text. Neither the community nor the individual had yet identified a problem to be understood; however, this student copied word for word from the book about plant growth. During class time, she referred to this as 'her work' and frequently asked to continue doing this work. When asked why she chose to do her notes on chart paper, she explained '*that this way, everyone can see the notes and know what I am doing'*; the information became available to the community and community could see her contribution. Figure 4.10 shows a sample of this student work.

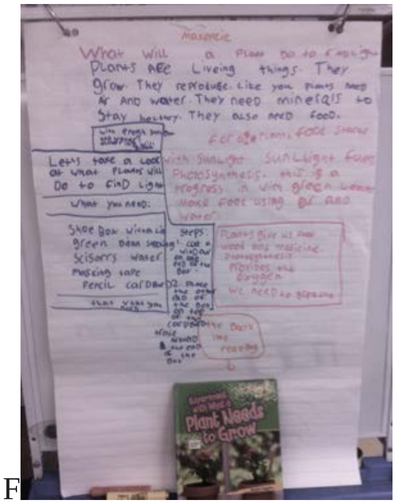
F

Figure 4.10. Example of student work made available to the community.

Interestingly, another student began some plant experiments that she had found after looking at the various age appropriate texts, with real-world examples and, step-by-step experiments. As with the previous student, this student did not, to my knowledge, question the authority of the text. After looking at the book and asking if she could take it home, this student brought materials from home and set them up on the back shelf with the book and some Post-it notes to record data. When asked why she brought the supplies in from home and set them up, she said, "*I need to understand how plants grow.*" She found the experiments in the books and said she "*thought they looked interesting.*" When asked why she put them on the shelf, she explained that she thought everyone could see them and it might help the class learn about plants. In both this example and the previous example, it is plausible that both student see this sharing with the community as an act of generosity in that they want others to receive their knowledge.

Figure 4.11. Example of student work made available to the community.

In the light and shadow unit, two students identified that they needed to understand how rainbows work. They found an experiment in a book, which used coffee filters and black ink and placed the cup by the window for everyone to see. Figure 4.12 shows a picture of this work.

In and around this same time, a student approached me and, having noted that there was an increasing amount of student generated work appearing around the class suggested that we should have a *"space to put all of our experiences so that everyone can look at them and see what's happening. Maybe we can leave them on the back shelf over by the window…"* This remained the case until the end of the year.

Figure 4.12. Example of student work made available to the community.

After exploring gears in the science unit on simple machines, students worked together to show the current state of their knowledge for the group to obverse. They choose to display it on the SMART board for the class. We asked why, they stated that they want to make sure everyone could see it.

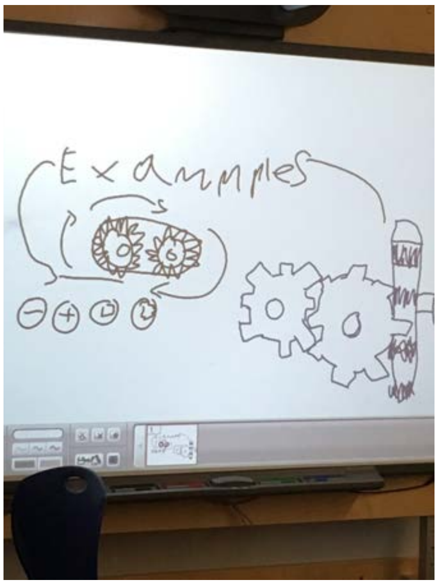


Figure 4.13. Example of student work made available to the community.

As one of the principles of knowledge building related to community knowledge, symmetric knowledge advance is described as expertise distributed within and between communities and that the understanding is that to give knowledge is to get knowledge (Scardamalia, 2002). This knowledge building principle was evident in design projects as students distributed roles among the smaller teams in order to accomplish a greater end product. Student interviews regarding the design processes further suggest that students viewed others as resources. This student, learning English as a third language, explained how she used the community as a resource when she was designing a boat.

Teacher: Why did you make a wedge at the front of your boat?

Student: Help it move forward so it can move more.

Teacher: Can you tell me about how your ideas improved as you worked on it? How did you improve your ideas?

Student: So first, I tried it (the boat) just a square box. Then I asked the class if I need a wedge they said yes so I made a wedge.

Alternatively, the following student potentially saw himself as a resource for the group. Late in the year, he referred back to an earlier unit of study and asked the following:

Student: Do we have a document about plants?

Teacher: No, we began that unit before the technology was ready so we did not create a whole class document.

Student: …because I have some new plants at home and I wanted to take pictures of them to add to the document. That way everybody can see them.

As the school year continued, self-organization of the group resulted in community knowledge. Bereiter (2002b) explains that adopting the way of thinking about knowledge and mind necessary for knowledge building requires a mindset that sees learning, thinking and knowledge creation as forms of self-organization. Gilbert (2005) compares this self-organization to a clade: unspecified groups of organisms that colonize the new environment created when an event upsets the balance of nature. Evolutionarily speaking, clades are the exact opposite of clones. “Clades represent diversity, dynamism, innovation and ongoing life, while clones signify conformity, constriction, and eventual death” (Gilbert, 2005, p. 128). Gilbert (2005) concurs with Bereiter (2002b) and the need for self-organizing structures. These structures were evident in two ways over time.

Firstly, students continually improved their technology skills, considered to be a part of Popper’s World 2 mental artifacts (Bereiter, 2002). This was evident, as many students became proficient using tools that were not demonstrated in whole class lessons. Rather, the tools were found by way of exploration and then shared with the community during writing time. They were shared amongst students as they worked in small groups and they were shared during whole group conferencing.

Secondly, the data suggests that the community continually redefined their ideas of what a story is, which represents a World 3 conceptual artifact. In this environment, they collaboratively designed new ways of telling stories, using features of the technology in unique and novel ways relevant to the community. They added transitions, external links, speech bubbles and animated graphics interchange format (GIF) files. The students created multimodal text. In tracing the development of ideas, by looking at the student work, samples of rise above become evident as student pulled ideas from one project and added to the idea to create something new. Throughout, no identifiable leader managed the group. Examples of these texts and more detail regarding the use of GAFE as a tool to support the collaborative efforts within the community are provided in a subsequent finding.

A shift in culture was not all encompassing by the end of the year. Analysis of evidence also illustrated students who continued to show ownership of ideas and to see others as competition. In our writer's workshop, a team of two writers shared some current work. Another student was inspired and wanted to write the next book in what she saw as a potential series of books. When she asked if she could build on the ideas of others, she was told no. As she reported to me: *"I want to write a story like theirs but when I asked them how to do it, they said it was their idea and I couldn't write it like they* *did. I don't get it. We are allowed to copy and make our own Pusheen (*character in trade book*) books. How come I can't make my own book like theirs?"*

As well, in the last science topic of the year, feelings were hurt when one person wanted to start a 'Green Team' club and, after sharing the idea with the class, another group forged ahead and made announcements and posters for a similar club without including the first child. Rather than work together as resources, they saw themselves as competitors for the idea.

Further, as one student was working on a design, another approached to offer an idea for improvement. According to this student, she told him *"to go away because it is my project and I am doing it alone."* The first student explained to me that he was frustrated because *"you can have ideas from other people to help with your project but (she) told me that she didn't want my idea because it was her project and she wanted to work on it alone."* Not all students were accessing the community as a resource.

Others students continued to work without support from the community. In a design project, as a student was asked the following:

> *Teacher: Did you get any feedback from the community about how you might improve your design?*
>
> *Student: No.*
>
> *Teacher: Would you like some?*
>
> *Student: I'm okay.*

These examples suggest that ongoing work is necessary to support students into considering various participant structures and how these structures foster the desired interactions for knowledge building. These examples might also suggest that some students do not yet see idea improvement beyond the individual level and that ideas do not belong to everyone. It might be that they see an idea as private property.

In sum, evidence suggested a shift in students as they began to see themselves as resources for one another, compared to early on in the year when there was a strong desire to work independently. However, while there was a shift in the classroom community, there continued to be instances of individuality and ownership of ideas. This ongoing ownership, however, may present opportunities for future designs in knowledge building.

Finding 3: Student Activity Selection Based on a Need to Understand

When considering which knowledge building principles might possibly reflect student activity selection, evidence of epistemic agency is most relevant. With epistemic agency, participants do not rely on others to chart the course of knowledge advancement for them; rather, they seek to negotiate a fit between personal ideas and the ideas of others (Scardamalia, 2002). In regards to this particular knowledge building principle, the tabular data is discussed below. Following the summary of tabular data, excerpts from the data analysis are discussed to expand upon the numerical summary provided in the tabular data.

The data displayed in Table 6 shows epistemic agency was present throughout the year. Specifically, in the first initiative, 9 instances of epistemic agency were captured. The second initiative and third initiative captured 6 and 17 instances respectively and the final initiative captured 8 instances of epistemic agency.

The data in Table 8, which summarizes the use of the scaffolds for knowledge building, highlights that the scaffold closely connected with epistemic agency, ‘I need to understand…' was also present throughout the year. Specifically, there were 41 instances of "I need to understand' during the Plant and Plant Growth Topic; it was in this topic that students had two opportunities to engage with a identified problems as they began first with Post It® Notes and then moved to using GAFE. In the second topic of investigation, Light and Shadow, data collection captured 31 instances of 'I need to understand.' However, the data in Table 8 also shows a decrease in the amount of times this scaffold was used during the third and fourth initiatives with 12 and 13 instances captured respectively. This might be explained as students took up the work of knowledge building in groups and identified the group need for understanding as opposed to individual needs for understanding, which might account for the decrease in the use of the scaffold. The following excerpts highlight a few of the instances of epistemic agency that were captured in each of the initiatives described above.

As some students began to identify various needs for understanding, we spoke, as a whole class, about different ways that they might address these needs. The criteria presented to the students was that, whatever they chose as a next step, they had to be able to, at any given point in time, articulate what it was they needed to understand and what their plan was to address the identified need. The following teacher reflection was made after this whole group conversation.

> *One student said to me, 'Wait… so we can watch the Magic School Bus again if we want to?' to which I replied, 'well, what do you need to understand?' The student explained that he needed to know more about rainbows and wanted to watch the episode. I replied that if his plan made sense and he could watch it. By the end of the class that day, there were kids reading books, a group gathered*

around a computer watching a video and some kids were making jot notes. (Teacher Reflection, October 20, 2016)

This small group of students took on epistemic agency from early in the year and were able to articulate needs and plans.

Along with the above example, further evidence highlighted that multiple students demonstrating epistemic agency based on an identified need to understand. For example, the following interaction shows a student initiated conversation one-on-one with the teacher.

Student: I need to understand if a plant can grow without dirt.

Teacher: Can you design something that would help you understand?

Student: I could put a sunflower seed in a cup of water and leave it by the window.

This student followed through by setting up the experiment as per her design. Further, she left the activity out in the open for others to see, which might also support the suggestion that some students were shifting their understanding of community knowledge as outlined above.

Figure 4.14. Example of student-initiated next steps for learning

As we moved away from our Plant unit of study and into our Light and Shadow topic, a few students began to wonder if plants could grow without light. When asked how they might find out, one of the students suggested that we could set up a box with a plant in it and see how much the plant could grow. The group of three set up the experiment and along the way, they were surprised to note that the plant did grow. They redesigned the experiment when they decided to try to understand if the plant could grow with only a flashlight. Other students began to take notice of the experiment and would check on the plant each morning when they came into the class.

Further student-selected activities appeared as the year progressed. The following teacher observation was recorded during the Light and Shadow topic of study.

> *Two students approached me today with yellow paper in hand and asked:*
>
> *Student 1: Can we do an experiment?*
>
> *Teacher: Why? What do trying to understand?*
>
> *Student 2: We want to see what happens with light and the difference between white paper and yellow paper. So can we do it or not?"*
>
> *Teacher: Yes*
>
> *They took flashlights over to the corner of the room and start using shining it through different papers. Another student joined the area and joined in. I suggested that they could take pictures of what they were doing and upload them into the Google document. Student A replied, "I'm going to do that tonight."*
>
> *(Teacher observation, November 29, 2016).*

This small group of students identified a need for understanding, gathered the necessary materials and began their investigation.

This epistemic agency was present when another teacher came into the room. For example, when a colleague came in to cover the class for a period of time, he noted:

> *'I thought I would sing some songs and play my guitar for them(the students) but they were totally uninterested… they came in first thing and all grabbed computers and started to work. I had to see what they were working on and they all had on something different on the go but they were all able to explain what they were doing and why… it was amazing!' (Comment from colleague, April 20, 2017)*

Many students at this point were accustomed to and committed to working on the activity that they deemed relevant based on their own personal need to understand.

Along with epistemic agency, as a related knowledge building principle, there were some students who demonstrated an ability to work with real ideas and authentic problems in the activities over the year. The data in Table 6 illustrates evidence of real ideas and authentic problems during the first and second initiative. Recall that in the first initiative, students were provided with two opportunities to identify problems by way of identifying what they needed to understand. Students were introduced to knowledge building first with Post It® Notes and then asked to work further with GAFE. Data was collected and analyzed from both of these opportunities, which might account for higher incidences in the first initiative.

Data collection and analysis in the second initiative uncovered thirty-one instances of students identifying real problems that they needed to understand. Many of the questions in the second initiative stemmed from the introduction to light and shadow. Recall that this unit of study presented students with an opportunity to explore many phenomena through a variety of centers as an introduction to the unit. It might have been that the novelty and surprise involved in the introductory stations elicited many questions from the students, as noted earlier in the description of the design in chapter 3. The data in Table 6 below also shows a decrease in theory generation toward the two later initiatives. Recall that in the third iteration, students did not make individual documents. In attempt to bring the class together more, I shared teacher-created documents digitally with all students, resulting in fewer documents. However, as the data in Table 8 suggests, fewer documents appears to have resulted in increased input from students in regards to the knowledge building discourse.

The data in Table 11 seems to support these analyses in that there were instances of evidence coded under the sub-dimension of activities in the Social Infrastructure Framework, whereby activity selection was left up to students by way of real ideas, authentic problems and epistemic agency, as opposed to activities being tightly sequenced by a teacher. The following examples pulled from the evidence collected across all initiatives highlight the epistemic agency and real ideas, authentic problems in the students over the year.

While gathered together for a knowledge building check in through group discussion, students were asked to consider what next step might be necessary to help build their knowledge around our study of gears and levers. A student suggested, *"We could take apart things with gears or things that might have gears in them."* As some students continued to discuss the idea, one asked if she could bring her bike from home because the chain kept falling off and she needed to understand how the gears worked so she could fix it as it was her only bike. She brought it in, a fellow student began working with her and, when necessary, they engaged expert help to support their next steps.

Figure 4.15. Example of student-initiated next steps for learning

At the same time, a different group of students identified a need to repair the pencil sharpener that had been broken for the bulk of the year. They suggested that this would also be a way to better understand the gears and why the sharpener continued to malfunction. A small group of four students worked together over time to investigate.

Figure 4.16. Example of student-initiated next steps for learning

After students worked with a variety of simple machines, they were asked to design a simple machine that related to a problem they identified. Many students struggled initially, with only one group deciding that they needed to design a simple machine that could carry messages across the room. Most students were successful when they were asked to consider the problem in a different way. Specifically, students were asked to consider that if they could design anything for a favorite toy, what would they design? From this point, many students in the class successfully designed, tested and redesigned. The designs included boats, elevators and cars for transporting toys. Making the problem more meaningful by connecting it to the immediate world of the students might have supported the students in their design efforts.

In sum, the findings of this research suggest that some students were productive when they were given the opportunity to select activities based on self-identified goals. This was in contrast to presenting students with a tightly sequenced set of activities to be followed throughout the year. As well, the data collected and analysed suggests that some students demonstrated epistemic agency by way of identifying a need to understand along with possible next steps.

Finding 4: Students' Perception of the Purpose of the CSCL Tool Shifted over the School Year

The practices dimension, according to Bielaczyc (2006) concerns the ways in which teachers and students engage in both online and offline learning activities relating to the technology-based tool. This practice involves considering the activities in which to engage students and the related products. In reviewing the evidence, it can be argued that the students shifted their views on the purpose of the CSCL tool, specifically GAFE, over the course of the school year. Table 10, which consolidates the analysis of the evidence in regards to quality and frequency of scaffolded discourse, shows the following. Chit-chat was present from the beginning of the school year and continued to grow, presumably in part as more students became more proficient with the tool. With early initiatives, some students struggled with log in issues, creating and sharing documents. Toward the second half on the year, all students demonstrated proficiency with the skills required to log in, create, share and contribute comments to a document.

Table 10 also shows an increase in idea sharing as students began to add images and links. Students also began to edit each other's work for clarity and accuracy, based on observations of revision history provided in GAFE. Idea co-construction, mainly by way of asking questions of each other and the contributions became increasing evident over the school year and was especially evident in GAFE for the last initiative of Waste in our World.

Table 11, using the Social Infrastructure Framework for analysis, supports that evidence was present related to the as purpose of the CSCL tool, specifically in regards to how students see GAFE, how GAFE was being used to carry out the knowledge building objectives and how it fits into the overall workings of the classroom. The following examples of evidence pulled from student contributions to GAFE elucidate this shift in perceived purpose of the tool.

Originally, students created their own documents and shared with whom they wanted. This elicited few, if any, contributions from others in many instances. Note that the document in Figure 4.17 below has questions about flowers generated by a single student. However, there are no comments along the right hand side of the document, which is where contributions from fellow students would normally appear.

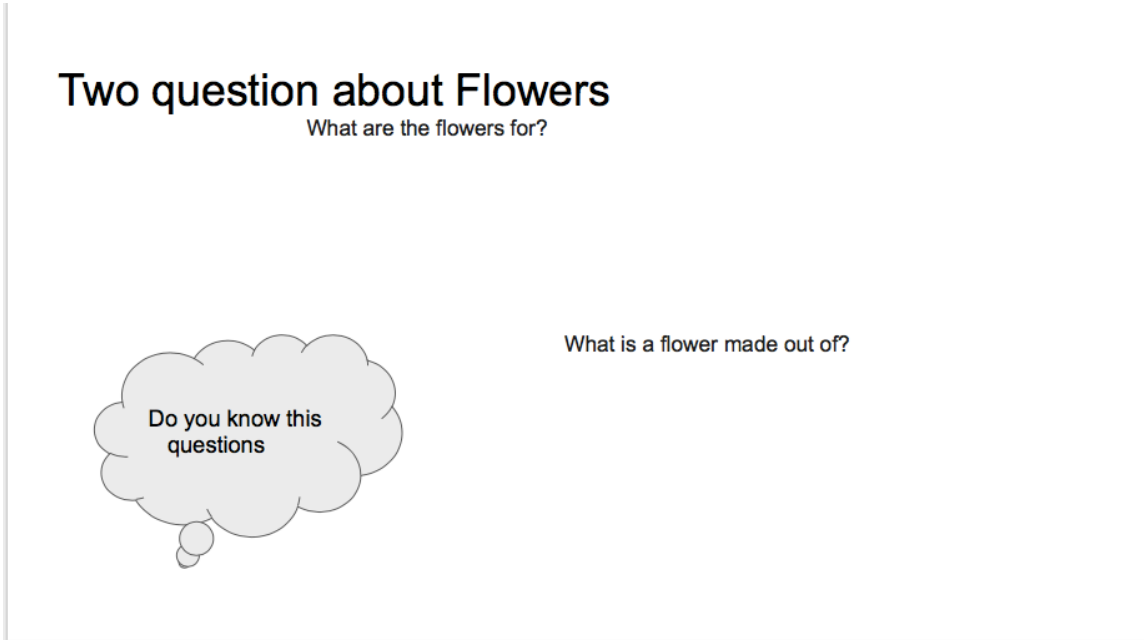


Figure 4.17. Student contribution to GAFE with no peer response

An important design decision was made after the first two initiatives. Early on in the school year, students created their own documents and share with a limited number of peers. In an attempt to bring the community together, I created seven documents for the science topic of study and shared them to all students in the class.   In shifting the design so that one document was teacher-created and shared with all students, an increase in the number of students who contributed to the document was evident. Figure 4.18 provides an example of this, as multiple students have made contributions of some sort to this document.

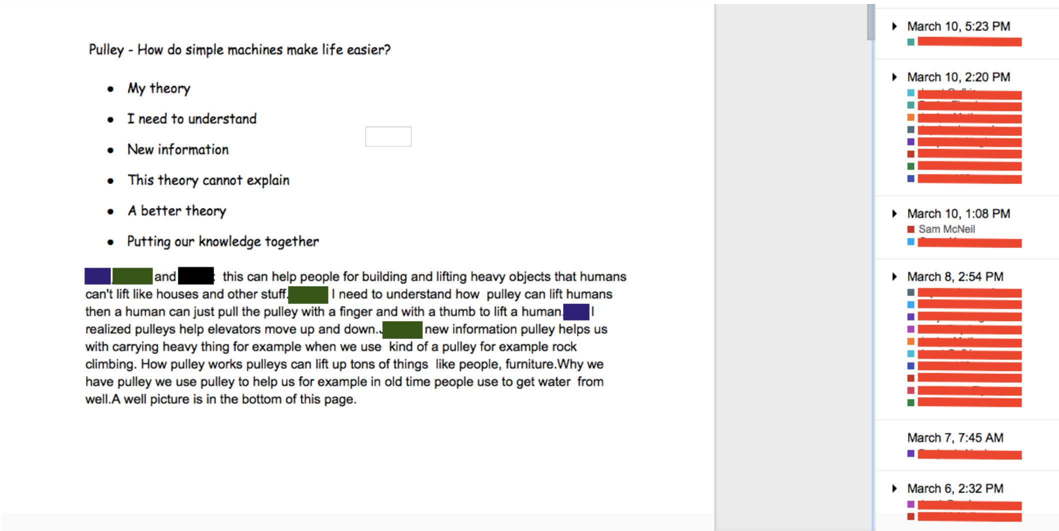


Figure 4.18 – Multiple student contributors to GAFE

In Figure 4.18, note multiple contributors along the right hand side, each marked by different colored squares. Further, there are contributions within the text from the group members who created the original document, as noted again by the colored bars. In all, eleven different students have made a contribution of some sort to this document.

In shifting from student-created documents shared with a few to teacher-created document shared with all, an increase was noted in the number of students contributing to the document. The student-created documents received comments from fewer students compared to the teacher-created documents, which saw more contributions from more students. Each color in the body of the text in Figure 4.18 represents a different contributor, as do the colored squares along the side bar. This is in contrast to the previous document where there were no fellow contributors. This might be explained by increased ability among the students to use the tool or perhaps an increased sense of trust might have existed among contributors. It might also be explained by a shifting understanding of the purpose of the tool, in that with this tool, students are afforded the opportunity for connections among peers. However, the tool does not track the number of views or visitors; it could still be conceivable that views were different than contributions. This shift in student-teacher-machine-physical-space configurations did result in increased access to information from all contributors as opposed to limited access when students shared with only a few peers. Figure 4.19 provides an additional example of the use of the tool, as multiple students have made contributions of some sort to this document.

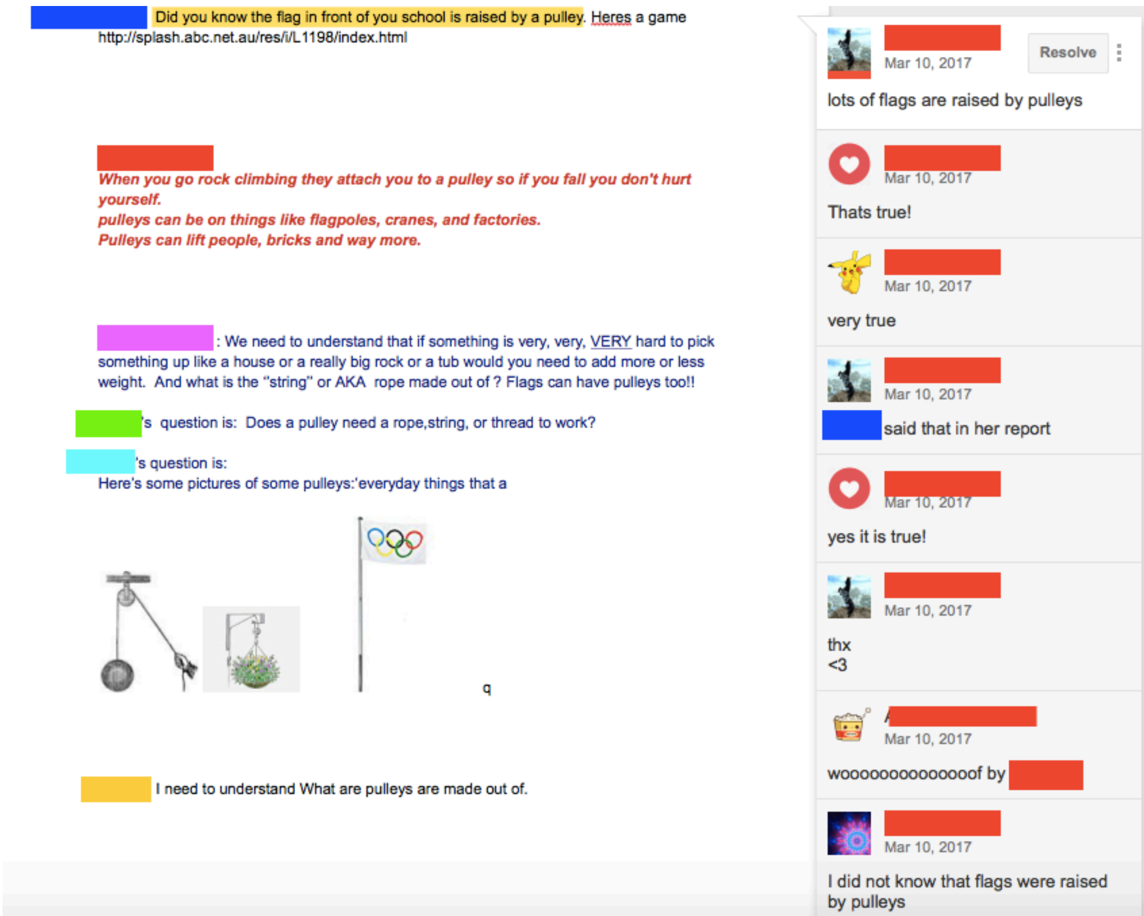


Figure 4.19 – Multiple student contributors to GAFE

Note that each color in the body of the document represents a different contributor. Each icon on the side bar also represents a different contributor. This increased number of contributions suggests that students are beginning to understand the functionality of the tool and that the tool allows for opportunities to participate in the work of others. This image also shows examples of idea sharing, as the student shares a link to a game using pulleys, it shows examples of chit-chat by way of the emoji in the side bar, and it shows new information as a student adds to the group knowledge regarding flags and pulleys. Finally, it also shows some students identifying new needs for understanding, specifically how pulleys might work with things that are '*very, VERY hard to pick up*'.

Recall from the data in Table 10 that the student contributions to GAFE continued to increase throughout the year, with increases in chit-chat, idea sharing and idea co-construction over each initiative. Knowledge co-construction was mainly present in the form of questioning. Figure 4.20 shows early examples on contributions to GAFE that consisted mainly of chit-chat.

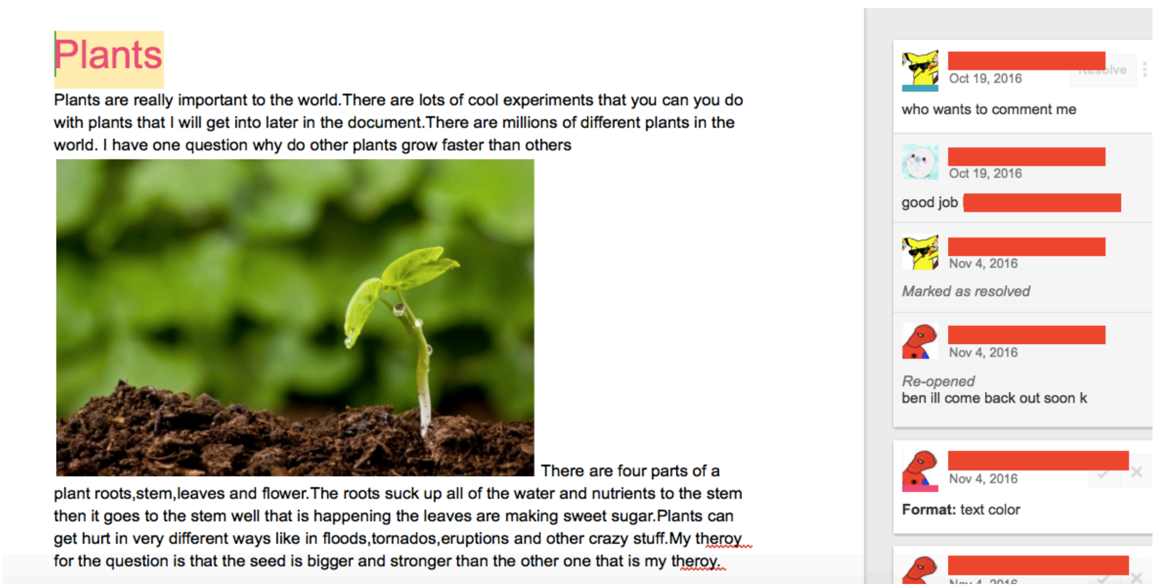


Figure 4.20 – Chit chat in GAFE

The contributions here consisted of general feedback and casual conversation. There was also a change of text color, which did not result in meaningful improvement or development of the ideas.

In comparison, figure 4.21 demonstrates this shift in the purpose of the tool. As students continued to engage with the knowledge building principles and the scaffolds, the contributions began to shift by way of questioning. Note that at this time, students reverted to creating and sharing their own documents. These documents detailed their design efforts in response to identified problems of waste in our world. In the figure below, students are beginning to ask questions of each other.

Figure 4.21. Example of student co-construction by way of questioning

The document above shows multiple contributors along the side bar. The student contributors raised questions about the problems with the fruit flies in relation to the sorting issues identified at school in seeking to understand the connection between fruit flies and sorting trash.

It was at about this same point in the school year when the previously noted student requested a document because he wanted to take pictures of his newly purchased plants so that others could see them. This request from the student might have suggested that he saw that the CSCL tool, specifically GAFE, could be a place to add to the current body of knowledge, which the community could then access.

Some students also began to see the tool as a means to collaborate. At times, they designed new ways to collaborate using the technology, especially during the writer's workshop time, where students were provided time and space to work on topics of choice as opposed to structure writing assignments. At one point, the community began a new story with ten co-authors. The following conversation helped to provide further understanding of this work. During a parent-teacher interview, this collaborative story was discussed with a student and a parent.

Teacher: How did you get involved with the ghost story?

Student: I think that the idea is that all students will be involved at some point. At least, that's what I think the goal is.

Teacher: How is it that other students join into the project?

Student: Kids wandered over and looked at what we were doing and then they asked if they could join in. I think the idea is to get all of the students in the class to work on the same story. Someone comes up and asks what's going on and then we just share it with them."

Student's mom: "Can you share it with everyone?"

Student: "I, uh, well I just need to know everyone's emails… I think I have them all."

Mom (to student): "Have you share that story with me yet? I don't think you have."

Mom (to teacher): "I just think it's amazing how these kids work with technologies and how we can see right away what they're working on. I get a 'bing' on my phone and I can see what they are doing and give them a comment right back."

These approaches to writing were innovative ideas for some in this given community. In their previous years of writing, based on conversations with some of these students and fellow teachers, story writing was often based on a prompt, worked independently, a pencil and paper task, and submitted to the teacher for review. Examples of the student-generated ideas are provided in Figures 4.22, 4.23 and 4.24 below.

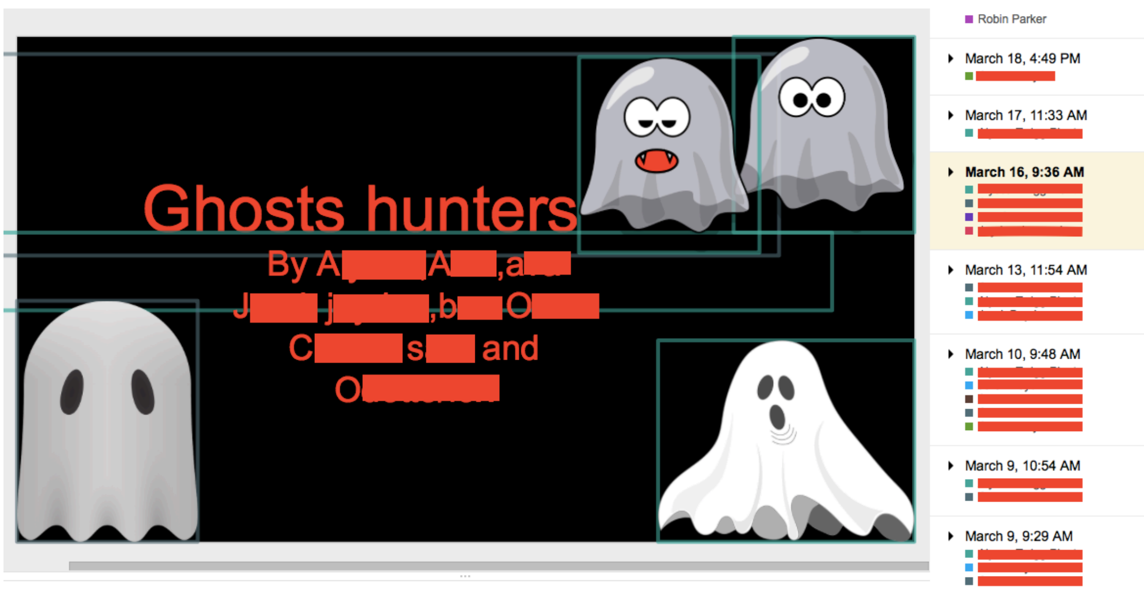


Figure 4.22. Example of multiple authorship as collaborative use of tool

Note that there are multiple authors listed on the main page of this document. As well, the side bar shows contributions from multiple students. This example lends support to the finding that some students were beginning to see each other as resources; this story became the collective responsibility of a group in the community.

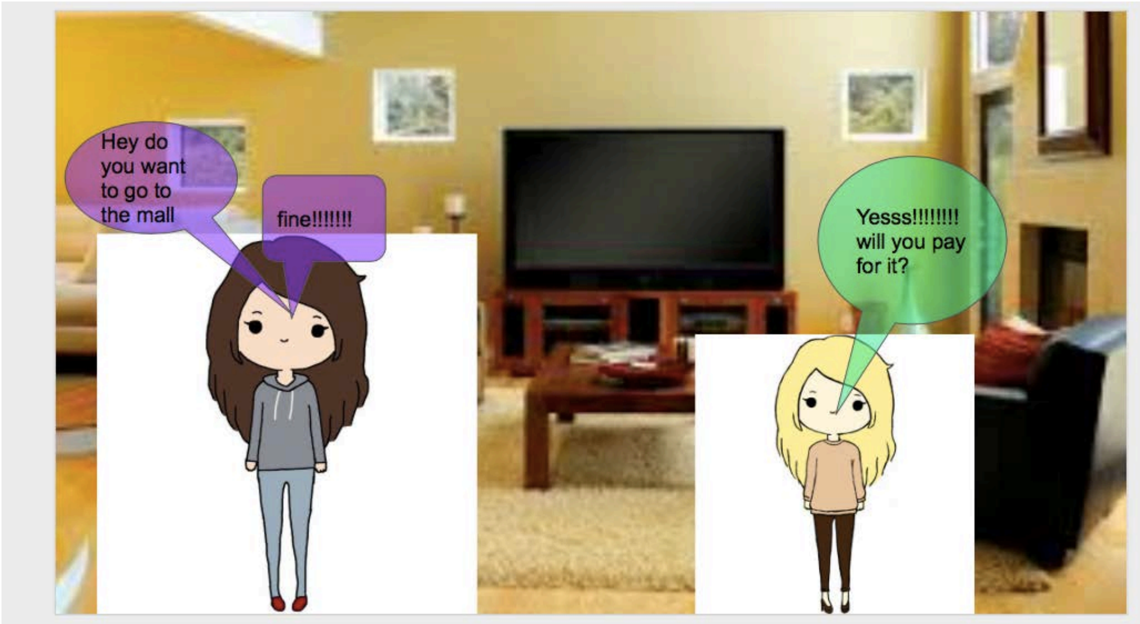


Figure 4.23. Example of original story concept evolved through collaborative use of tool

Figure 4.23 is an example of an advance in community knowledge by way of collaboration. A small group of students began writing more graphic style novels, adding details such as background, setting and dialogue, based on the contributions from other students as opposed to structured, whole class lessons on graphic novel design.

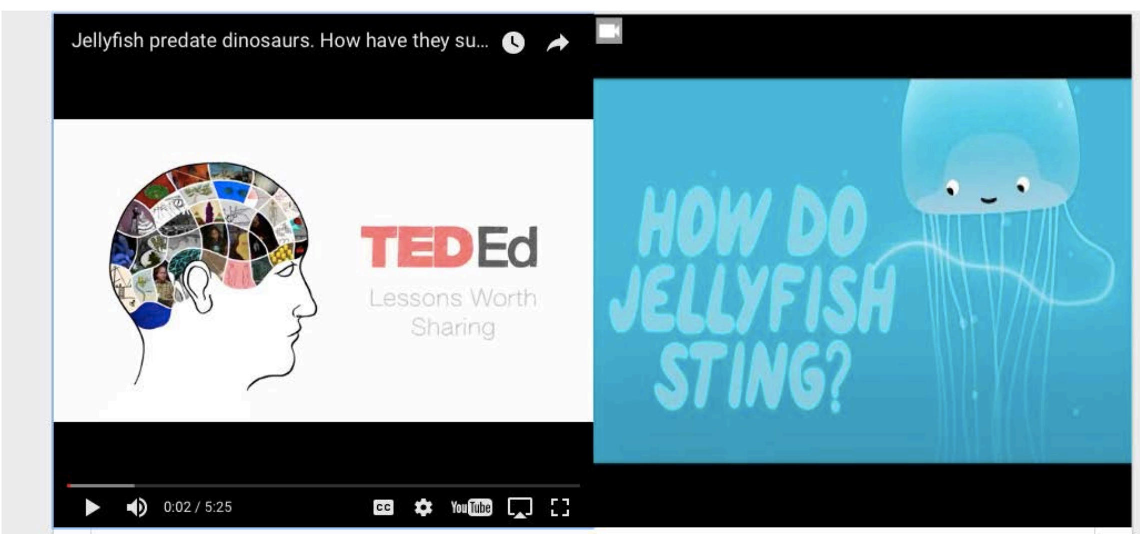


Figure 4.24. Examples of multimodal stories evolved through collaborative use of tool

A small group of students created the document depicted in Figure 4.24 as a non-fiction text about jellyfish. This was based on a student-identified need to understand more about this creature. With both the opportunities for networked collaboration and the functionality of the tool to allow for links and video, the group of students produced work beyond that of the classroom instruction, in essence creating multimodal text. It might also be considered an example of a rise above as, based on the revision history of the document and observations made of this group, the students worked together to create something beyond what either individual had created in the past.

In sum, student contributions to GAFE as the CSCL tool began in limited ways, both in terms of quantity and quality. Over the year, both the quantity of contributions to GAFE increased and the quality moved from chit-chat toward idea diversity and co-construction. The samples provided in the results of Finding 4 in contributions suggest that, over the course of this action research, some students in the sample have come to see how the CSCL tool can be used to carry out identified learning objectives and how GAFE fits into the overall workings of the classroom.

Finding 5: Access to Technology Supported a Cultural Shift Toward Knowledge Building

Bielaczyc (2006) explains the socio-techno-spatial relations dimension in reference to the organization of physical space and cyberspace as they relate to the teacher and student interactions with technology-based tools. Wireless handheld devices that permit mobility and modularity are considered. This dimension influences accessibility, connectivity, and communication among students and teachers (Bielaczyc, 2006).

As noted earlier, the configuration of the technology shifted midway through the year. Initially, computers were organized in a common space referred to as the computer lab and housed in the school library. At this time, each classroom teacher signed up to use the lab when they felt it was necessary or appropriate. The computers remained locked in the lab, despite being laptop computers. The shift in organization involved sharing computers out to all rooms rather than housed in a central location. At this point, the grade 3-4 classroom had 4 iPads, 4 Chromebooks and thirteen laptops.

Once in the classroom, the laptop computers were organized in the physical space based on proximity to electrical outlets. However, careful consideration was given to further classroom design so that students would see technology as available to all rather than stored behind the teacher desk and potentially perceived as controlled by the teacher.

The access to technology became available to students on an as needed basis as opposed to a given block of time during the day when the computer lab was ‘signed out’ by the teacher. Some students accessed technology multiple times per day for multiple reasons. Some students used the technology to work collaboratively during writing time, to create documents, to track and share their new understandings in science and in design thinking, and to respond to the identified needs for understanding. It was explained to students that they did not need to ask to use technology; rather, if they had technology, they needed to be able to explain the purpose of the technology. Specifically, they were asked to explain what they needed to understand and how the technology was supporting them. Indeed, students managed the technology with limited teacher intervention. Several students stopped asking permission to use laptops; rather, when asked why they were using a computer, many students were able to articulate purpose. For example, two students sat together to watch a video. When asked, they stated, *"We are trying to learn more about rainbows so we are watching the Magic School Bus again."* Further examples involved the students referred to earlier in social studies, who returned to search the Internet with the intention of addressing the classroom identified needs in further understanding the First Nations, as described earlier.

All students were invited to bring personal devices into the classroom. Over the course of the year, three students brought in personal devices. Specifically, one student brought her Chromebook and two students brought in iPhones. While these devices were used at times, the students eventually reverted to using school-owned devices. When asked, one student explained that the network was unreliable and it was difficult to either log in or maintain a connection. She stated that she was frustrated and stopped bringing the Chromebook back and forth to school.

In sum, the physical changes in the storage of the computers resulted in a cultural shift in regards to how some students accessed and used technology. Access initially was limited but became more available as needed over the year due to these physical changes in storage.

Limited Findings

Beyond these key themes that have emerged from the analysis of the evidence, the analysis also highlights that, while students engaged with all knowledge building principles, there was limited evidence in regards to certain knowledge building principles. For example, Table 8 shows that there was limited evidence of the constructive us of authoritative sources among students. Hooks for knowledge building often included authoritative sources, including video clips from NASA regarding plant growth in space, video clips explaining current design technology for recycling, and guest speakers. Further to this, students were provided with direct instruction on the criteria for authoritative information, including corroboration, reputation and expertise. A few students were able to note if information was corroborated, or if it came from an expert; these students tended to be the students who generally presented stronger in terms of overall academics.

Analysis of evidence shows limited interaction with the outside world. Attempts were made to bring knowledge into the classroom by way of class visitors and field trips. These visits entailed preplanned activities that were, at times, aligned with discussion patterns that limit knowledge building rather than those that enable knowledge building. Other visits supported idea improvement by way of design tasks prepared for the students. For example, some visits included the initiation-response-evaluation (IRE) loop whereas other visits included designing and redesigning a landfill with limited IRE.

Extending the audience for the work occurred in limited ways. One example of this occurred when a student had taken it upon herself to share her work in GAFE with a parent, who was quite excited. As previously noted, a parent explained,

> *"I just think it's amazing how these kids work with technologies and how we can see right away what they're working on. I get a 'bing' on my phone and I can see what they are doing and give them a comment right back."*

This would suggest the audience for student work was beginning to expand, albeit, in this case, incidental as opposed to intentional.

In sum, while there were opportunities for students to interact with the outside world and while criteria were introduced to support students in constructively engagement with authoritative sources, including outside experts, limited evidence was captured. It is possible that the designs were not sufficient in supporting this aspect of the work. It could also be that evidence was present but not captured by way of observations or reflections. As limited evidence was noted, it was difficult to draw out themes from the evidence that did exist.

Summary

In analyzing the evidence from the designs for knowledge building, I would argue that shifts over the course of the year occurred in what Bielaczyc (2006, 2013) has termed the cultural dimension, especially in regards to how the some students understood their social identity. Specifically, some students came to see themselves more as learning resources for each other rather than competitors. Further, there was evidence that some students were coming to reconsider what it meant to know by their increased willingness to engage with idea improvement. It was toward the end of the year that a shift in how some students viewed the purpose of GAFE became evident.

Further advances that supported knowledge building occurred within the practices dimension. Some students took on the work of determining next best steps and related tasks, demonstrating epistemic agency from early on in the year. This was balanced with teacher task design early on in each of the initiatives to support students in what Bereiter (2002b) calls sufficiently intimate terms with the object to be understood.

In applying the Social Infrastructure Framework (Bielaczyc, 2006), it became apparent that limited interactions with the outside world might have affected overall design efforts. Further to this, redesign is necessary to continue to support these cultural shifts for more students.

Chapter 5

Discussion

This year-long practitioner action research project began in response to various educational initiatives at the provincial and local levels aimed at developing engaged thinkers and ethical citizens with an entrepreneurial spirit, who strive for personal excellence, who employ literacy and numeracy to construct and communicate meaning, and who discover, develop and apply competencies across subject and discipline areas (Alberta Education, 2013). As well, this research was taken on in response to my own revised understandings of how knowledge can be defined and a desire to better understand knowledge building in an elementary classroom. As a teacher, I questioned my own practice to determine how I might better meet the needs of my students in this age of knowledge.

Whereas chapter 4 separated out pieces of data to tell the story, the intention of this chapter is to reconstruct a holistic understanding of the outcomes of this study and to provide interpretive insights into the findings from chapter 4. This chapter addresses two key areas: (a) how the research questions are answered by the findings, and (b) how the findings relate to the literature. Following that discussion, the chapter turns to an analysis of the implications of the research and suggests next steps for both classroom practice and future research. The chapter concludes with the significance of the research.

Discussion of Findings

This research was bound by the following research question: What learning designs enable a class of students to engage in knowledge building? Further questions involved exploring: a) How do students engage with the knowledge building principles as defined by Scardamalia (2002); b) what is the quality of scaffolded discourse in computer supported collaborative environments; and c) in what ways can knowledge building support design thinking in the classroom?

Before committing to a discussion of each of the research questions, an attempt was made, on my part as the teacher-researcher, to consider the findings in a deeper way and to consider possible reasons regarding how the findings might be explained. An interpretation outline (Bloomberg & Volpe, 2012) was created using an inductive questioning process and asking ‘why’ and ‘what are the other possibilities?’ over and again to brainstorm all the possible explanations for the findings. This approach to analysis was an effort to develop and strengthen my critical thinking and reflection (Bloomberg & Volpe, 2012). It is hoped that this systematic search for rival or competing explanations and interpretations helped to establish the credibility of this study (Bloomberg & Volpe, 2012). A completed interpretation outline is included as Appendix F. After reviewing and considering the data, the following understandings emerged in relation to each of the research questions.

When considering the designs for knowledge building in this action research, the findings support that some students were able to advance in knowledge building as they worked together to improve ideas of value to the community. Further, students engaged with all knowledge building principles with varying degrees of frequency as a result of the designs implemented over the course of the school year. Over time, scaffolded discourse in GAFE shifted in its purpose as students took up the work of knowledge building. Additionally, design thinking allowed further opportunity for some students to continually improve ideas, supporting a further enculturation into knowledge building. Each of these findings in now discussed in greater depth.

Question 1: What learning designs enable a class of students to engage in knowledge building? In brief, the designs for knowledge building over the course of the year involved several consistent elements. A hook for learning was consistently used with each knowledge building initiative in an effort connect to student experiences and trigger student-generated questions. As recommended by Friesen (2015), these hooks for learning included presenting challenges to the students, sparking their curiosity about a subject through questioning, and introducing relationships to the world outside of school.

Further to the use of the hooks, Google Applications for Education was a consistent design element and used as a digital space for externalizing, articulating and tracking the progress of the work of knowledge building (Sawyer, 2014), with documents first being created and shared by students, followed later in the year by teacher created documents shared with all.

Knowledge building scaffolds were introduced to the students to support the work of CSCL. These scaffolds included ‘My theory is’, ‘I need to understand’, ‘This theory does not explain’, ‘A better theory is’, and ‘Putting our knowledge together’. These scaffolds were used consistently with each knowledge building initiative as well as beyond the CSCL environment and incorporated by design into the day-to-day work and thinking routines of the classroom where and when possible.

Further elements of the designs included physical designs in the classroom when planning for knowledge building and ongoing work to support diversity of ideas was considered in math class. Opportunities for design thinking were sought in order to promote knowledge building and, as with the scaffolds, were incorporated into the workings of the classroom in an ongoing manner. In attempt to answer the above research question, each of these elements of the designs will be addressed in turn.

Generating real ideas and authentic questions by way of a hook for learning. With knowledge building, Bereiter & Scardamalia (2010) argue that, "producing 'real ideas' to address 'authentic problems' is not an occasional excursion, it is one of the cardinal principles of the approach" (p. 3). Scardamalia & Bereiter (2006) warn that, when knowledge building fails, it is usually because of a failure to deal with problems that are authentic to students and ones that elicit real ideas, or in other words, those that are meaningful. Implementing designs to allow students to generate authentic problems was essential.

Knowledge building "begins by getting students on sufficiently intimate terms with the object to be understood so that they can ask some *why* questions with some meat" (Bereiter, 2002, p. 126). Jåravelå and Renninger (2014) suggest that designs should attempt to trigger interest in content through novelty, challenge, surprise, complexity or uncertainty and that, further, designs need to make connections between the real world and the content to be learned. A hook for learning was consistently used with each knowledge building initiative in effort connect to student experiences and trigger student-generated questions. These hooks for learning included presenting challenges to the students, sparking their curiosity about a subject, and introducing relationships to the world outside of school (Friesen, 2015). It was anticipated that the variety of hooks used for each topic would allow for real ideas leading to authentic problems.

For example, in an effort to get students on intimate terms with the Plant and Plant Growth topic, students were introduced to the unit with a variety of video clips exploring the current work in the discipline. For example, NASA scientists are currently examining how plants grow in space and how this can inform our work on Earth with plant growth in less than ideal environments. From this, the students were able to identify their questions:

I need to understand:

Why the plant needs dirt or soil?

I need to understand how the sunlight helps a plant to grow?

Why does the plants have stem and roots too?

I need to understand if a seed can grow in shade?

I need to understand why is the photosynthesis so important?

How do seeds transform?

I need to understand if plants can live in just water with no dirt.

Later in the year, in hopes of triggering interest and surprise in the phenomena of light and shadow, students played with shadows, reflection and refraction in a variety of center activities (See Appendix F). This hook also resulted in student-generated questions for knowledge building:

Why did the penny disappear when I added water to the bowl?

How come the colors blended together?

Why did the pencil look different in the water?

How did the bird end up in the cage when I spun the paper?

Why did my face look upside down in the spoon?

Why did the arrow change direction when I looked at it through water?

Why does the light change when you shine it through a cup of water?

Hooks continued to be used throughout the year, including the final topic of Waste in our World. In attempt to connect this topic to our daily lives, the students and I examined our school data, provided by the head office of the school board, to understand how much waste we produce as a school in comparison to other schools in our system. Further, we closely examined the waste generated by our school on a daily basis by dumping the trash bins, taking photos and making notes as a way of observing and documenting our findings. This hook generated the following questions and problems from the students:

Why are there are a lot of chip wrappers in the garbage?

Why are people are throwing out food that has not even been touched! There was an entire sandwich in the garbage, still in a baggie!

Why do people put the juice boxes in the garbage but they just put them in the recycling instead.

There are so many fruit flies by the compost…its gross! What are fruit flies doing here?

There are a lot of granola bar wrappers on the ground, especially the corner piece that you tear of to open the bar.

I watch people just throw their garbage on the ground. Why don't they just put them in the can?

Why are people putting their recycling in the wrong container?

People throw out a lot of baggies!

Resendes & Dobbie (2016) remind us that “promising questions are deep and rich, engage the how and why of a problem, and are not easily Google-able” (p. 101). As previously noted in the findings section, the hook that produced these promising ideas was the one that most connected to the students’ daily lives at school. Moving forward for knowledge building entails seeking out ongoing connections to student life. Real ideas and authentic problems are those that the learners formulate themselves because they care deeply about them (Scardamalia, 2004).

Further, the topic of these real ideas and authentic problems should be ones that allows students to “contribute to a body of knowledge and make a difference in the real world” (Friesen, 2015, p. 65). As a teacher, I have come to understand that Bereiter and Scardamalia’s (2010) notion of contributing to a body of knowledge can include that of the classroom body of knowledge and that the classroom itself constitutes a real world community in which knowledge building can occur. Generally speaking, Bereiter and Scardamalia (2010) explain that, when thinking about contributions to a body of knowledge, “the examples that come to mind are likely to be works of genius” (p. 2); however, they further explain that “it is plausible that naïve learners can create knowledge to aid in their creation of further knowledge, and that classrooms can become knowledge creating organizations in their own right” (Bereiter & Scardamalia, 2010, p. 12). Over the course of the school year, I came to better understand how and why the contributions of the ‘naïve’ learner matter to the classroom. These contributions, although they might seem small to the outside observer, are meaningful and exciting to the students. For example, students identified a need to understand if a plant could grow without light and designed a way to test. When it did begin to grow, students began each day by checking and reporting the progress before any other task. I argue that this was a contribution that advanced the knowledge of this community.

Based on my observations and the students' experiences throughout the year, I concur with Friesen (2015) and Jåravelå & Renninger (2014) that a hook can effectively invite students into a topic for knowledge building. Student questioning does not end with the hook, however, as student questions continued to be raised throughout the topics of study. Further to the plant example above, the students were well into the topic of Plants and Plant Growth before a student-identified, '*I need to understand if a plant can grow without soil'* and then worked to design an experiment to seek understanding. Much later, after we had moved into the topic of light and shadow when a small group of students raised the question regarding plant growth without light. While a hook for learning consistently allowed students to generate initial questions, it was important for me, as the teacher, to be aware of further promising questions. Scardamalia, in conversation with Resendes and Dobbie (2016) explains, "this is one of the things that knowledge building teachers do that is so understated. It's not 'the guide on the side', it's not facilitation, it's finding and cultivating sparks" (p. 30). An early theme in my teacher reflections was that noticing these sparks was difficult when faced with the complexity of the day-to-day workings of the classroom. Rather than advantaging student comments and questions as sparks, I noticed that I was often attempting to provide direct answers. This was captured in the following teacher reflection in regards to a class discussion on simple machines:

> *At one point we were sitting around the carpet and just about to wrap up a conversation on simple machines. As some kids started to move about, one of the*

> *students continued discussing and suggested that the textbook was a simple machine. Despite the chaos, I had the wherewithal to ask her why she thought that was the case. She explained that 'the textbook helps make work easier". In the moment I did not recognize this as a misconception or as a possibility for knowledge building moment. It was only the next day when I was thinking back then I realize how powerful that moment could possibly be. Around the same time in that class, one of the students mentioned that the SmartBoard was a simple machine. In response, I simply stated no, it wasn't. I failed to notice in this moment, the student was presenting his theories and it could have led somewhere had I realized it earlier. (Teacher Reflection, February 13, 2017)*

As the school year progressed, the busyness and complexity of the classroom certainly remained. I did, I believe, become more aware of the importance of cultivating these sparks, and I began to use the knowledge building scaffolds more consistently in prompting students when they asked questions. For example, I would ask students 'What's your theory?' rather than provide direct answers when possible. During group discussions, I began to prompt other students in response to questions raised, again by using the scaffolded language. For example, I would ask, 'Does anyone else have a theory? Does anyone share that need for understanding?' I recognize that, with the complexity of the room, I sometimes missed opportunities to spark students' knowledge building; however, awareness of the importance of these moments increased and my efforts to attend to these small moments that elicited promising questions also increased over time. The success of knowledge building relies on the generation of promising questions that are meaningful to the community. In this work, I would suggest that designs that include a hook for learning can provide such an opportunity. Beyond this, however, it falls upon the teacher and the students to be aware of promising questions that might contribute to knowledge building as students become more familiar with a topic over time and look for ways to advantage these rather than simply provide direct answers.

Scaffolds support a shift in classroom culture necessary for knowledge building. In a well-designed CSCL environment, scaffolds are used in an effort to support students as they move toward achieving learner outcomes (Verdú & Sanuy, 2013). Prompts are a form of scaffolding often used with students and aid students as they plan, monitor and execute analyses and investigations (Reiser & Tabak, 2014). These prompts may be verbal, written or embedded within technologies.

The consistent use of the knowledge building scaffolds, both in GAFE and in guided discussions, supported a necessary shift in the cultural beliefs in the classroom. Davis et al. (2015) explain that “humanity carries its history of thinking along in its customs, it languages, and its artifacts” (p. 5). Cultural beliefs, as noted by Bielaczyc (2006) “are not usually thought of as something that (are) designed. Cultivated may perhaps be a better way to describe the approach required. The point is that the beliefs held by teachers and students within a classroom setting can indeed be changed” (p. 304).

Specifically, these beliefs included how learning and knowledge were conceptualized, how students viewed their social identities, how students understood the teacher’s social identity, and how the purpose of the tool, in this case, GAFE, was viewed (Bielaczyc, 2006). These cultural beliefs shape the way of classroom life and influence how a technology-based tool is perceived and used. Bielaczyc (2006) states,

> in cultivating the necessary cultural beliefs that support the work of CSCL, consistency is important, and classrooms that attempt to change aspects of the social infrastructure for only a short period per day or a short period during the course of a school year may have a difficult time creating a successful learning environment. Providing sufficient time for any needed changes to occur is a critical design factor. (p. 322)

Based on my study, I would concur with Bielaczyc (2006) and suggest, based on the data collected and analyzed, that consistently using the scaffolds in and out of CSCL, as opposed to using them for a short period of time each day, was a way to cultivate these cultural beliefs. For example, when students brought their story writing to the 'Author's Chair' and asked the group for specific feedback, they came to recognize that sharing was not just about 'show and tell' or 'three stars and a wish' but rather sharing with others was about continually improving ideas. One student, at the end of the year, reported, *"I have changed in so many ways as a writer; I didn't know there were so many ideas out there! I really like the Author's chair because I got so many ideas!"* Further to the culture of ongoing idea improvement, students worked pervasively on their stories; they alternated between projects, coming back to certain projects with promising ideas. On limited occasions, students shared work with parents, who commented and contributed.

Some of these scaffolds were used in daily life in the classroom, without prompting, by multiple students. For example, while on a field trip to a local science venue, a student noted, after watching a movie about robots, that *"Ms. Parker, I have an 'I need to understand about robots. I need to understand how they talk."* This unprompted comment was made during a lunchtime break, in the midst of casual conversation.

Further to this, when sharing a design early in the year, one student was receiving feedback from the class. His response to the feedback was that it was his project and he *"didn't want to change it."* However, later on in the year, the same student was sharing a piece of writing with the group and stated his need for understanding around certain plot points and the development of his story. As the group began to lose focus, the student sharing stated, *"Shhh! I want to get as many ideas as possible for this story and I can't hear!"* Over the course of the year, this student came to see sharing as opportunities for improvement.

Based on her research with teachers, Bielaczyc (2006) notes that a culture where students sustain effort towards idea improvement is necessary and takes time, perhaps as much as a year. Specifically, in her research, Bielaczyc (2006) reported that teachers felt that it was in the second year with the same students that the class began to work on a communal level. The "longer that the students 'lived' in the culture, the better able they were to establish and assimilate the relevant philosophy and norms" (Bielaczyc, 2001, p. 107). Recall that Davis et al. (2015) explain that, in regards to philosophy and norms, a community is viewed as a situated collective of learners with its own coherence, evolving identity and a similarly coherent and evolving situation.

In light of the evidence gathered, I would concur with Bielaczyc (2006) and Davis et al. (2015) and I suggest that cultivating a culture where students worked communally to build knowledge is ongoing work beyond one academic year. This idea of working together to build knowledge was a new concept to both me and this group of students;

much of the work over the year involved working from scratch to redefine the learning community to embrace a culture of knowledge building. I would suggest that in a complex and diverse context such as the one studied, a year allowed multiple students to engage with all of the knowledge building principles to some extent. However, it is worth noting that other students, by the end of the year, continued to struggle to contribute to theory generation or community knowledge. For example, feedback from a parent late in the year revealed that her child felt uncomfortable when asked to develop theories, as she was "*afraid that she was going to be wrong.*" This student, despite spending a full year in the classroom and working with theory generation, idea improvement and collective knowledge continued to see knowledge as external, stable and objectively real as opposed to incomplete, biased and unavoidably partial (Davis et al., 2015). Another student, when offered an unsolicited idea for a design improvement from a classmate late in the year stated, '*It's my idea. I want to work on it alone.*' Here, this student saw the idea as something that belonged to her rather than something that lived in the community to be worked on. Her classmates were not considered resources at this point but potentially competitors. These examples lend support to Bielaczyc (2006) in claiming that a shift in cultural beliefs, including students' conceptions of knowledge and learning, takes time.

In considering my own reflections as a teacher and looking back over the designs used throughout the year, it is fair to say that more time was spent on providing students opportunities to work with some scaffolds over others, specifically generating theories, identifying what they needed to understand, and finding new information in effort to promote a shift in cultural beliefs around student identity, teacher identity and conceptions of knowledge and learning. For example, early on in the year, when asked what she needed to understand about plants and plant growth, a student responded, with frustration, *"I don't know what I need to understand."* This same student, later on in the year, was able to begin to identify her next steps by using the scaffolds is stating, *"I need to understand if the moon gets its light form the sun. I need to understand how India gets light."* This focus on using these particular scaffolds resulted in less time spent on the remaining scaffolds, including, 'This theory does not explain', 'A better theory,' and 'Putting our knowledge together.' In looking across the data, the use of scaffolds, both those in GAFE and those used verbally to guide discussions, did support the students in knowledge building. Further discussion on the quality of the scaffolded discourse in GAFE is provided below.

Idea diversity in the math classroom. As a part of the overall math program, students were provided with multiple opportunities each week to work with questions that allowed for multiple responses. These questions, referred to as open-ended questions, were designed to uncover student understandings and misunderstandings, and to differentiate math instruction (Small, 2009). In providing this opportunity to students, it was hoped that they would begin to see math as more than one correct answer, and as an opportunity to view the body of knowledge as more complex, interrelated concepts, and never quite being satisfied with final answers. Examples of an open-ended question used in class include the following:

1) Describe a time where a number definitely tells how many.
Describe a time when you are not sure.

2) 25 and 50 – What's the same and what is different about these two numbers?

3) Write an addition question using the word 'less'.

Open-ended questions were used throughout the year. Modeling was provided to support students who were unfamiliar with this type of questioning and students worked with increasing independence as the year progressed. Responses were consistently shared with small and large groups to allow students to see variety in responses.

Students were consistently presented with open-ended questions at the beginning of each math class. Early in the year, students would find one answer to the each of the questions presented and state, *'I'm done.'* However, as time passed, students produced multiple answers to the questions and acknowledged that some questions could never be done. At one point, a student wrote the following on the large classroom whiteboard: *'Sometimes there is more than one answer in math.'* This was an unprompted comment and remained on the board for several weeks. I would suggest that, based on the increased diversity in responses to these questions over the year, this design, specifically the use of open ended questions as an introduction to math each day, supported students in seeing the possibility of idea diversity in math and moved them away from always thinking that math was something to be 'done' or completed by way of a single answer. This was evident in their math journals and in math discussions as the number of responses generated over the year consistently grew.

However, while idea diversity was present, the continual improvement of ideas in the math classroom presented a challenge, especially when, as a teacher, I was responsible for a curriculum heavily focused on the utility of the number system. As a teacher new to knowledge building, I often wondered where and whether the curriculum presented any opportunities for theory generation and idea improvement?

In past years, Alberta's curriculum was developed one subject at a time and over different time periods, resulting is no common design across subject areas. For example, the curriculum in social studies is presented with essential questions for inquiry that might support a teacher in looking for a beginning point for knowledge building. On the other hand, the math curriculum is presented as a list of skills, procedures and facts to be taught, without essential questions or big ideas that could possibly elicit ideas for knowledge building. For me, as a teacher-researcher new to knowledge building, I felt more confident in designing for knowledge building in social studies and science, where theory generation seemed more workable as opposed to the mathematics curriculum, which presented more of a challenge in regards to theory generation and the continual improvement of ideas of value to a community.

Close examination of the conceptual framework and instructional focus in the kindergarten to grade nine Program of Studies in mathematics reveals the following. Knowledge is identified as personal. Students are expected to communicate in order to express their understandings as opposed to building them. Teachers are encouraged, when planning for math instruction, to consider that learning mathematics includes a balance between understanding, recalling and applying mathematical concepts (Alberta Education, 2016). This curriculum design stands in contrast to the idea of knowledge building, where knowledge lives in the community and is meant to be continually improved.

Looking at the specifics of the Program of Studies, we see that ‘Number Sense’ is listed as a general outcome at all grade levels. From there, a number of specific outcomes, representing facts, rule and skills are listed for each grade level. For example, specific grade four outcomes listed under the general outcome of ‘Number Sense’ include, but are not limited to:

- Apply the properties of 0 and 1 for multiplication and the property of 1 for division
- Understand and apply strategies for multiplication and related division facts to 9x9
- Recall multiplication and related division facts to 7x7
- Demonstrate an understanding of addition of numbers with answers to 10 000 and their corresponding subtractions
- Compare and order numbers to 10 000. (Alberta Education, 2016)

The curriculum is filled with a specifiable set of facts, rules and skills. Bereiter (2002b) argues, “number sense is clearly something attributable to individual minds. But it is not any specifiable set of facts or rules or skills. It is an attribute of the whole system not a lot of items in a mental container” (p. 15). Bereiter (2002b) reminds us of the ‘mind as a container’ metaphor which is prevalent in education and suggests, regarding number sense, that this metaphor “fails miserably when we try to deal with sorts of knowledge and skills that cannot be defined as items in a container but that instead characterize the whole container” (p. 15). When presented with a curriculum focused on facts, rules and skills, knowledge building can be a challenging approach to enact.

Making this an even greater challenge is, once again, the notion of culture. Recall that Davis et al. (2015) suggest that humanity carries its history of thinking along with its customs, languages and artifacts that act as layers of knowing. Further to this, they explain that, “despite the distaste one might feel toward, for example, a ram-it-in-cram-it-in model of teaching, that conception is knitted into the culture of education. It may be suppressed, but it will always be present in one form or another” (p. 5). In the case of mathematics, with local standardized test results decreasing in the area of mathematics, this history of customs, languages and artifacts has started to become evident in my local setting as parents, administrators and teachers question current math practices. This culture and these conversations can contribute to the challenge of knowledge building in mathematics class.

Resendes and Dobbie (2016) suggest that there are approaches that teachers can take to knowledge building in a math classroom. “Students can tackle a pre-defined math problem or they can grapple with a real life problem where math is emphasized” (Resendes & Dobbie, 2016, p. 75). In this, certain knowledge building principles can be engaged, including knowledge building discourse, idea improvement, with a focus on collaborative discourse over arriving at quickly at right answer, and constructive use of authoritative sources (Resendes & Dobbie, 2016). While the designs in this action research did not necessarily lead to evidence in relation to these particular principles of knowledge building, I would add that idea diversity and collaborative discourse are possible in the mathematics classroom as students tackle open-ended math problems.

Physical designs toward knowledge building. A significant shift in the physical design of the classroom came with the reorganization of technology in the school. Early on in the academic year, computers were housed in a common space in the school library and referred to as the computer lab. In and around January, computers were shared out to all classrooms. This resulted in access to technology on a more ‘as needed’ basis for children for the remainder of the year, as opposed to a scheduled block of time to go to the lab as a whole class. As well, as a result of the shift in physical designs for technology, it was not feasible to provide a structured lesson in technology for all students with a computer in front of them at the same time. However, the norm instead became that the students were recognized as experts in various areas of technology and they supported one another in the classroom, again on an 'as needed' basis.

The computers were stored openly and students did not have to use permission to access the technology. The expectation was that, if students had technology open and in use, they could be asked to explain what they needed to understand and how they were using the technology to support this need. This was a dramatic shift from earlier in the year, when technology was only available to the students if the computer lab was booked in advance. Technology became available on an as needed basis, with students responsible for assessing the need. The intention of this redesign with the technology was to support a shift in cultural beliefs around the purpose of the tool and to further contribute to building a learning community with philosophy and norms that supported work in and out of CSCL. As well, it was hoped that this redesign would support the reification of epistemic agency where a student had a right and a responsibility to decide when and where technology was needed.

With the technology more readily available, students became recognized experts in technology and were asked to share their expertise with other. When technology issues arose, I would often ask the class, "Who are the experts with this technology problem?" Students consistently volunteered and successfully solved various issues. In conference with a parent at the end of the year, she reported that her child spoke excitedly about helping others: *"He came home and he was so excited that he could help others. He told me, 'Mom, Ms. Parker called me an expert when someone needed help with the computer!!'"* It is interesting to note that, while only one formal lesson was provided on how to login to both the school Internet and the GAFE, almost all students showed growth in their technology skills over the course of the year, due in large part to community knowledge and collective responsibility. This was evident in that almost all students no longer required support to log on, create and share documents, create and share presentations, search the Internet, and find copy and paste images. In sum, based on my experiences with this research, I would advise those teachers who might be interested in taking up the work of knowledge building that access to technology in an ongoing basis supports a culture for knowledge building. As opposed to a computer lab, where classes sign up to visit at predetermined times, computers in the classroom support the efforts of the students by allowing them access when needed and promoting epistemic agency among students.

Based on the data collected and analyzed, these designs lead to a shift in the culture necessary for work in the knowledge-building classroom, as discussed in the previous chapter. These designs further allowed students to engage with knowledge building principles. The following section addresses the second research question and discusses in detail how students engaged with these principles.

Question 2: How do students engage with the knowledge building principles as defined by Scardamalia (2002)? Knowledge building principles include real ideas and authentic problems, idea diversity, improvable ideas, rise above, epistemic agency, community knowledge and collective responsibility, democratizing knowledge, symmetric knowledge advancement, pervasive knowledge building, constructive uses of authoritative sources, knowledge building discourse, and embedded, concurrent and transformative assessment (Scardamalia, 2002). There are many benefits to using principles in that they can facilitate the enactment of classroom innovations and can also provide a blueprint for the cultivation of a new classroom culture (Fu, van Aalst & Chan, 2016). The intention of this action research was to design in such a way that all knowledge building principles would be reified in the elementary classroom.

Scardamalia (2004) acknowledged that knowledge building principles are often considered to be more abstract and less procedural, which can be problematic for teachers trying to bring knowledge building to life with students. The abstract nature of the principles was challenging but important. In that they were more abstract than procedural, it allowed me, as the classroom teacher, to be more reflective of what was happening in the classroom and, as much as possible, be on the lookout for opportunities for the continual improvement of ideas. Further, in that they are more abstract helped me, and continues to help me, consider my own understandings of the principles and the relationships between them. If they were more procedural, it may have lead to more of a checklist of knowledge building rather than a continual advancement of the work.

When considering the data holistically and reflecting on this research questions, the following understandings come to light. Overall, the data collected suggests stronger evidence of some knowledge building principles over others. The scaffolds most commonly used over time by students included ‘My theory is…’ and ‘I need to understand’, suggesting that students were increasingly open to identifying real problems, authentic questions and idea diversity. I concur with Scardamalia and Bereiter (2006), in that "generating ideas appears to come naturally to people, especially children, but sustained effort to improve ideas does not" (p. 100). Tarchi et al. (2013) suggest that idea diversity can be a good introduction for newcomers to knowledge building; I would agree with Tarchi et al. (2013) in that idea diversity was evident from early on in the year; multiple students generated personal theories quite readily when asked, beginning in the first initiative.

To be sure, a shift in culture was not all encompassing by the end of the year. There were examples in the data of students who continued to show ownership of ideas. *"I want to write a story like theirs but when I asked them how to do it, they said it was their idea and I couldn't write it like they did."* In the last science topic of the year, feelings were hurt when one person wanted to start a 'Green Team' club and, after sharing the idea with the class, another group forged ahead, made announcements and posters for a similar club without including the first child. Rather than work together as resources for one another, they saw themselves as competitors for the idea.

Students demonstrated epistemic agency early on, as evidenced in the first initiative on plants and plant growth. Recall students who were setting up multiple experiments to understand plant growth. Moss and Beatty (2010) suggest that there is no straightforward way to identify epistemic agency; however, the extent to which students use scaffolds may be taken as evidence of epistemic agency. I would concur and suggest that, based on this action research, the students' abilities to articulate what they were learning, why they are learning it and how they know they have learned it would be an indicator of epistemic agency.

Connected to this principle of epistemic agency, my research suggests that students brought their knowledge into the community by way of sharing or displaying work that they had taken up in effort to better understand. Students were making their knowledge available to the community, and the data collected suggests that collective responsibility also present. Individuals were intentional in sharing their work. Through knowledge building discourse, both small and whole group, there were instances of intentionality. For example, some students identified a need to *'take apart things with gears'* to further their understanding of simple machines. Further to this, the following conversation demonstrates both democratization of knowledge and symmetric knowledge advance as students worked to put their knowledge together. When discussing refraction during the topic of light and shadow, a student discussed how a plastic cup, filled with some water and placed in front of a picture, magnified the picture. This was much like what we did at the beginning of the semester with our light and shadow experiments. She noticed that the image was magnified but needed to understand why. The following conversation was captured.

> *Student #1: I didn't understand why that picture looks bigger when I look at it through water…"*
>
> *Student #2: There were molecules in the water and they are round…*
>
> *Student #3: ...oh yeah! Sometimes when things are round, it can make things seem bigger. Like if it is convex instead of concave.*

This small group of students was able to put knowledge together regarding the scientific phenomenon to reach a better understanding.

According to the data collected, the designs included in this action research resulted in limited evidence of both pervasive knowledge building and constructive uses of authoritative sources. Some evidence did exist for these principles and this evidence was noted in the previous chapter. However, these principles were noted with less frequency than other principles. This variation might suggest that future design efforts could include more opportunities to engage these principles. Or, it might suggest that the evidence collected did not accurately reflect the work with these principles. As students spend more time working with the goal of knowledge building and further possible shifts in culture as a result may lead to increased evidence of these principles in future.

In looking back over the data, there is limited evidence of the knowledge building principle of embedded assessment. Further, there are few instances of the use of the scaffold 'This theory does not explain…' which involves assessing the current state of knowledge in and among the community. Scardamalia (2003) explains that, with knowledge building, the community engages in its own internal assessment, which is more thorough than external assessment. Friesen (2015) discusses assessment as a dimension of discipline based inquiry and notes the following characteristics, where assessment:

- guides student learning and teacher's instructional design
- is woven into the design of the inquiry study, taking place in both groups and in self evaluation
- requires clear criteria that students help to create and use to set goals, establish next steps and develop effective learning strategies

- requires the involvement of teachers, peers, and adults from outside the classroom of students.

In the original design of this study, assessment opportunities included a student rubric to support internal assessment and determine next steps for knowledge building. However, because students were unfamiliar with rubrics, assessment became part of the whole group knowledge building conversations rather than taken on by students independently.

In considering my reflections by way of journaling on how students engaged with knowledge building principles, I can say that I was surprised how students at this age have already developed conceptions of knowledge and learning, along with understandings of their identifies as students. These identities might have limited knowledge building for some students in the beginning. It took much more time and effort to shift these conceptions that I had anticipated. Further, while I had considered epistemic cognition relevant to knowledge building in early research designs, I came to understand that enculturing students into knowledge building goes beyond conceptions of knowledge and learning and includes the social identity of the students, social identity of the teacher and the views on technology that all work together to define a classroom culture.

Looking across all data, it is clear that students engaged with some knowledge building principles more frequently than others. These differences were evident across both student contributions to GAFE, and with the physical artifacts created outside of GAFE. However, Scardamalia, in conversation with Resendes and Dobbie (2016) explains, “the 12 principles are components of a complex process and the really good news is that any single one that you unlock helps unlock the others… focus on whichever one appeals to you" (Resendes & Dobbie, 2016, p. 74). In unlocking some principles more than others, the community advanced in their knowledge building over the course of the year.

Possible next steps for practice. I see much potential in continuing my teacher design work with the knowledge building principles and the scaffolds. With this, ongoing whole group discussions to continually revisit what we mean when we talk about a theory and how we can continually redefine what we mean when we say theory will be of value. This will provide ongoing opportunity for students to consider what a theory is and how we can improve it. Students also need to continue to work with the criteria for idea improvement and be able to respond to the question, 'How do we know when a theory has been improved?' My intention is to draw specifically to Bereiter's (2016) criteria:

- It explains more facts
- It excludes more false statements
- It connects to other explanations
- It explains things in more detail
- Parts of the explanation interlock so that it becomes increasingly difficult to modify parts without altering the whole
- It is able to more clearly identify what it fails to explain
- It generates better predictions
- It explains how causal factors work, rather than only identifying and quantifying their effect

Depending on the audience, we may begin with fewer criteria and build throughout the year. For example, the data analysis included examples of students who successfully improved an idea by explaining in more detail; this might be an appropriate criterion for all students as they begin to further explore idea improvement.

Question 3: What is the quality of scaffolded discourse in the computer supported collaborative environment? Students' contributions to improve the collective knowledge in the classroom are the primary purpose of the knowledge-building classroom (Scardamalia, 2002). Bereiter and Scardamalia (2014) explain that,

> teachers who have tried to implement knowledge building without a supportive digital environment have simulated these environments with lower-tech devices such as sticky notes and pockets on a bulletin board. This demonstrates that, valuable as oral discussion may be in creative work with ideas, something beyond it is required in order to keep students' ideas alive as objects of inquiry. (p. 42)

To support the work of knowledge building, Scardamalia (2003) further suggests that Knowledge Forum® offers tools and features that best support knowledge building beyond what other various technologies might provide.

Recall that So et al. (2009) suggested that limitations and challenge exist with Knowledge Forum®. The text-based functions may not support diverse learners or younger learners with limited linguistic abilities. They further suggest that Knowledge Forum® is often limited in terms of availability in school environments in terms of the number of computers or scheduling around the use of computers. In the case of this research, Knowledge Forum® was unavailable. If, as Scardamalia and Bereiter (2003b) claim, a knowledge building environment should provide all students an opportunity to be on the inside of knowledge creation rather than looking on from the outside, limited access to technology should not stop the work of knowledge building from moving forward.

In this action research, Google Applications for Education was used as a digital space for externalizing, articulating and tracking the progress of the work of knowledge building (Sawyer, 2014). It is the tool that is widely available throughout the local school system; every child enrolled in the school system has been provided access by way of an email address. I would contend that, based on the data collected and analyzed, GAFE can provide a networked space to support quality knowledge building discourse. Further, GAFE is a tool that, I believe, can also reify the knowledge building principles. The data suggests that students began to take up the work of knowledge building with the support of some, but not all, of the scaffolds borrowed from Knowledge Forum® and Scardamalia (2002) in the GAFE community. The students' knowledge building work included both digital contributions to GAFE and in scaffolded group discussions and presentations.

Davis et al. (2015) contend that "technology is more than objects and tools; it refers to the ideas, practices, artifacts and sensibilities that define a culture" (p. 141). In this action research, I would contend that ideas and practices developed within the research context with the support of GAFE. Potential technological affordances were noted in working with GAFE. In this work, technological affordances are defined as the "temporal relationships between human and technological actors within networked social environments" (Parchoma, 2014, p. 367). Students communicated both in the body of the document and by way of comments inserted along the side to allow for multiple conversations. They inserted links and images as a way of providing new information to their fellow contributors to help move ideas forward; others were able to add comments in response to the contributions, stating for example *'I didn't know that'* or *'Now I get how a pulley works!'* or *'(Student) talked about that in her presentation.'* The students accessed voice typing when necessary, especially when typing was too cognitively demanding. As a teacher, I was able to access the revision history to further understand the development of the idea over time, including who contributed and in what sense. Comments were accessed in full to also help understand the progression of the community knowledge.

Based on data analysis, contributions to GAFE shifted purpose over the course of the academic year. With the advances in the quality of scaffolded discourses, I would argue that GAFE provided a networked space for joint problem solving (Tarchi et al. 2013). Using GAFE resulted in a shift from the computer as an instructional tool to provide facts and figures to that of a tool used to support collaboration by providing media, communication and scaffolding for production student interaction (Stahl et al., 2014). GAFE supported student sharing and questioning toward idea improvement. This was especially evident when classroom culture shifted in regards to student identity and purpose of tool, thus disrupting the flow of information in the classroom. Students' ideas and questions were contributed to a public space equally accessible to all, rather than information flowing through the teacher (Jacobsen, 2010). The data collected suggests that GAFE provided a digital space for externalizing, articulating and tracking the progress of the work of knowledge building (Sawyer, 2014).

I contend that students did not reach a stage of idea development, not because of the tool, but because of the absence of meta-discourse. While all knowledge building principles were used with varying degrees of frequency by the group and with the support of the teacher to assess the current state of the work in general, the contributions themselves were not assessed by the students to understand the quality of the scaffolded discourse. The descriptors were used by me, as the teacher–researcher; the students were not asked to look specifically at the quality discourse. That is to say, the meta-discourse was unintentionally overlooked.

I will continue to use GAFE as an environment to support knowledge building. It is the tool that is widely available across our school system and I believe it can be used in ways that extend beyond cooperative activities where "partners split the work, solve sub-tasks individually and then assemble the partial results into the final output" (Dillenbourg, 1999, p. 8). This research indicated that students were beginning to redefine their purpose of GAFE; opportunity to redesign in order to continue to support this shift is possible. This redesign will include more opportunities for formative assessment, as suggested by Fu et al. (2013). I will continue to use the following descriptors as I analyze the work in GAFE: 1) chit chat, 2) idea sharing, 3) idea co-construction and 4) idea development. However, my intention is that these codes will be made available to the community and the community will then be provided time to assess their work using these descriptors. With this work, they might be able to better direct their efforts regarding their contributions to the community if they can are more aware of where their current efforts exist and next steps for contributions (Fu et al., 2013). Further to this work, a next step might be to enhance the design for using GAFE. For example, student input could be solicited for the initial creation of the documents rather than made uniquely by the teacher, as was the case with the second iteration of the document creation and sharing, which may give the students more ownership.

Question 4: What relationships exist between knowledge building and design thinking? Design epistemology is concerned with generating useful ideas to resolve existing real-world problems (Koh et al., 2015). Bereiter & Scardamalia (2014) describe design thinking as a mindset, or a habitual way of thinking, rather than something to be turned on only for certain purposes. Further, Bereiter & Scardamalia (2014) argue that this way of regarding design thinking is especially appropriate for knowledge building in schools. If a design thinking mindset is reinforced through years of experience, it "should be something (students) carry with them into adult life. It would serve them in life's daily challenges and in whatever occupations they enter. It could be the most important thing they get out of school" (Bereiter & Scardamalia, 2014, p. 39).

Kelly (2016) highlights design thinking as a creative, collaborative way to transform education from a consumptive practice to a creative one. Data from this action research suggests that sustained effort to improve ideas was most evident during the design thinking tasks later in the year. When students had a physical artifact that did not work, they were more compelled to return to their conceptual artifact to redesign. In some cases, sustained effort on the part of the students resulted in multiple iterations of the design. This sustained improvement of ideas relates most directly with the following developmental strands that support the growth of creative capacity as identified by Kelly (2016):

- Generative development – the capacity to create alternatives for creative production, idea generation, 'fuel for creativity'

- Self-instigative development - greater learner autonomy, behaving with a sense of volition and choice, sustained motivation
- Experimentational development- testing and refining ideas
- Creative sustain development – sustaining recurrent iterations of idea generation and experimentation

For example, the images in Figure 5.1 below illustrates a student engaged in these developmental strands. This student demonstrated autonomy by way of identifying a personal need to better understand gears and designing in response to this need. She continued to test and refine ideas over several iterations. One iteration, as demonstrated in these images, involved refining the supporting structure for the gears, as the strings kept falling out of the tracks. As she explained, she was *"trying to stop the gears from moving so much so that the string wouldn't fall out."* This student sustained her efforts through numerous iterations as she experimented with different types of string and sizes of gears. She had further ideas in mind as she thought a good next step would be to try to use a gearbox within her structure as an alternative production.

Figure 5.1. Student design demonstrating developmental strands as identified by Kelly (2016)

Initial attempts to introduce students to design epistemology centered on a piece of fictional literature. Students were asked to use their knowledge of a story to design for a character in need. When presenting the first iteration of the design, one student stated, after listening to the class and fielding several questions, *"It's my project. I don't have to change it if I don't want to.'*

Others shared their work in small groups. After talking through the details of the design plans and also fielding questions, I asked the one group of students if they saw any opportunity for redesign. They replied that, no, they had nothing to add or change despite the conversations with peers. While the designs triggered questions regarding the characters and details in the story, and helped me to assess their understanding after having listened to the novel, it did not result in idea improvement for the majority of the students. The following teacher reflection highlights some of my thoughts related to the student work at the time, specifically in relation to real ideas and authentic questions

> *The (design) work we did with the novel study… (students) looked at a character who was in a desperate situation; they tried to design a way for this character to get out of the situation. However, while they understood how the character was feeling and they were responding to those feelings, there was nothing 'real life' that could have actually been done for those characters. It was a fictional setting, with an animal as the main charter, and so I wonder if that was getting in the way of developing their ideas. It wasn't based in a real life situation…I wonder if they are presented with a real problem, one that they really care about, if they would be more apt to look at their ideas and improve them because they really care about the outcome. Because they could see that the outcome might really impact someone in real life versus a fictional character. This made me think back to Bereiter's discussion on pseudo-artifacts and that, when we ask children to design or plan, children will be less motivated if there is limited or no possibility of the plan being enacted. They might learn something but there will be no knowledge building if we ask for pseudo-artifacts. (Teacher Reflection, February 3, 2017)*

This reflection highlights a point in time where I, once again, considered the importance of authentic questions and how those questions that are more meaningful to students might lead to more willingness on the part of the students to continually improve ideas. Design thinking in education often engages empathy as a starting point into student design efforts (Kelly, 2016). In this case, the students had empathy for the character, as demonstrated through our ongoing discussions and their reactions to events in the text.

However, even with this empathy, student ideas did always improve after feedback from peers. Future designs were, as a result, in response to student-generated problems with personal relevance.

As we continued with opportunities for design, evidence of students' continual idea improvement increased. This might have been because of a shift in the culture over time, where students began to see each other as resources over competitors and were more open to accepting ideas from others. Or, it might have been that the questions that sparked the design were more relevant to the students. For example, in trying to design a way to send messages across the class, one group explained

> *First, we wanted it to be a boat but we figured out that wouldn't work. The problem was that this is Styrofoam... we couldn't really get this thing floating. After that, we got this zip line idea. Well then, that didn't really work cuz you weren't really using stuff because it was supposed to be a straw and a balloon but there weren't any simple machines in it and then after that, we came up with this idea, with this (motions to a blow dryer attached to Styrofoam with wheels)*

Another student explained how he acknowledged the community as a resource in designing. In attempting to use air pressure to power a machine, a student explained, *the air needs to be pushing on the ground; this is the only way we can keep it there. So, we found this thing, that thankfully (another student)) handed this to us (motions to a very long tube, intended to be used to control the direction of the airflow).*

Some students continued to struggle with idea improvement, even toward the end of the school year. For example, after designing an elevator to move a stuffed animal between bunk beds, a student shared the design with the classroom community.

Teacher: so now you had some suggestions (from the class) about how to improve it... do you remember what those suggestions were?

Student: uh, no.

Teacher: One of them was about having a pulley at the top and the bottom so your sister could control it from her bed.

Student: you said we needed to improve it; I just don't know how to improve it cuz I like it how it is.

Despite receiving informed and detailed recommendations from the group, this student did not take advantage of the community knowledge nor did she engage in idea improvement. It might have been that this student did not see this idea as worthy of further improvement. Or, it might also have been that the student considered this object to this be a pseudo-artifact and, because it was not something to be used, the motivation to improve it may have been limited.

Generally speaking, idea improvement when designing concrete artifacts was more evident than improving abstract ideas. Or, it might have been that, in building concrete artifacts that did not function as expected, students understood opportunities for redesign more clearly. It was evident from the data that the students engaged in sustained idea improvement more frequently when planning, prototyping, testing and redesigning in relation to the questions raided during the Simple Machines topic of study. I wondered if, when the student could see that their device was physically not working when tested, it was easier to engage in idea improvement by way of trying to fix the fault. I am wondering if this experience early on in the year might help them to see that other ideas, especially theories, can be tested as well.

I would concur with Koh et al. (2015) in that, when engaged in design thinking, students are developing the ability to traverse Popper's three-world epistemology in a seamless way. Koh et al. (2015) argue this is essential to thriving in the fast-changing knowledge age. Students in this classroom demonstrated an ability to create a design, as a World 3 conceptual artifact, use the physical objects around them representing world to reify their conceptual artifact, revisit the conceptual artifact when necessary to consider alternatives, and add to their mental understanding of the content as demonstrated through teacher questioning and discussion of design choices.

In considering my own practice and how I have come to see design thinking, I have shifted my understanding. I originally saw design thinking as an activity as opposed to way of being in the classroom. In this way of being, Bereiter and Scardamalia (2014) advise that students are always looking for opportunities to design and redesign and to act on the basis of well-constructed ideas and understandings. Design thinking has been introduced to the work in the local school board as an approach rather than a philosophy. As a teacher used to follow the steps involve in an iterative design process, I now see design as a way of thinking. I would suggest that positioning design as a way of thinking might support teachers in understanding the value of design beyond an activity in the classroom.

In considering how I might redesign for the next iteration, I have decided to begin the next school year with a time spent on design mode with an emphasis on idea improvement. Because idea improvement was most evident when students were engaged in designing artifacts and thus working in in all three of Popper's worlds, continued work from the onset of the new school year may be a way to continue to shift the culture of the classroom toward continually looking for opportunities to make idea improvement common place.

The intention of this discussion was to provide interpretive insights into the findings from chapter 4. This included (a) how the research questions are answered by the findings, and (b) how the findings relate to the literature. From the insights, the following implications for both future research and classroom practice are suggested.

Implications for Practice

From this discussion, implications for practice exist as both a researcher and in terms of immediate next steps for teacher practice. This section will explore both.

Recommendations for further research. In considering potential next steps that stem from this research, multiple opportunities exist. To begin, in a multi-aged classroom, the intentions regarding configuration are for students to remain with the same teacher when moving from grade three into grade four. The students coming from grade two will all be new to the classroom. It would be interesting to compare the cultural positions and overall engagement of new students with students who remain in my class. What are the existing conceptions of learning and knowledge? How do students perceive their roles as students in the classroom? As well, it would be interesting to observe if or how the older students support the younger students with the enculturation into knowledge building.

Additionally, those students who transition into grade five will all be in a new classroom setting. It would be noteworthy to conduct classroom observations to uncover what they might take with them in terms of their conceptions about knowing and knowledge. Do they, in this new setting, continue to build and question theories, or identify what they might need to better understand without prompting? Is there evidence of student ownerships of ideas or ideas that rise above? What are their conceptions about knowledge and knowing? Do they enculture others into the work of knowledge building? Was a one-year opportunity to engage with knowledge building principles significant enough to shift conceptions about knowledge and knowing and do they continue to act on those conceptions?

It would be of great value to share this work with colleagues and, further, actively involve teachers in the work of moving toward knowledge building. This could mean introducing teachers to the knowledge building principles and the accompanying scaffolds. Teachers may agree to explore selected principles. For example, the Ontario Ministry of Education has selected real ideas and authentic problems, community knowledge & collective responsibility, and democratizing knowledge as the three key principles for focus in schools (Shaw & Massey, 2016). With this work comes an opportunity for teachers to learn the work by doing the work. It could potentially mean that teachers strengthen their own risk-taking attitudes and increase comfort with emergent design as student ideas taking the forefront (Shaw & Massey, 2016). Because it was found, in this action research, that the necessary shift in the classroom culture that allowed for students to participate in knowledge building was significant in terms of time and effort, it would be of value for teachers in the same school to work together to begin to build a culture from the onset that allows for students to assume collective responsibility for the continual improvement of ideas.

As noted early on in this paper, original designs for knowledge building included looking at student engagement in knowledge building in relation to both literacy and developing epistemic cognition. As a teacher-researcher, I continue to have questions regarding both literacy and epistemic cognition that, due to the circumstances of the classroom, have been left unanswered. I continue to have strong interest in these areas and can foresee moving forward with a focus on these areas of interest in my classroom.

As noted in this research, data collected and analyzed suggested that students engaged with some knowledge building principles more than others. It would be interesting to further investigate if there is any correlation between the frequency of a principle demonstrated and its epistemological sophistication. In other words, are the less frequently illustrated principles more conceptually challenging?

Finally, new provincial curriculum is currently under development in the province of Alberta. The projected completion date for kindergarten to grade four curriculum is spring, 2018 and subsequent ministerial approval is projected for December, 2018 (Alberta Education, 2017). Full implementation of new curricula across all grades is expected to be complete by the end of 2022 (Alberta Education, 2017). I believe there will be value in further exploring knowledge building and the accompanying principles as an approach to education that supports teachers as they implement to newly designed curriculum. Future research may be designed to investigate the potential relevancy of knowledge building to the new curriculum, specifically if or how knowledge building might support teachers in the implementation process.

Next steps for classroom practice. As a classroom teacher, I am committed to continually moving forward with knowledge building in my classroom. I see, because of the outcomes of this research, opportunities to continue with certain design elements. As well, I have considered what or how I might redesign as I enter into the next school year.

Beyond the aforementioned next steps for practice associated with each research question, as I continue to design for knowledge building, I intend to make further use of the Social Infrastructure Framework (Bielaczyc, 2006, 2013). Bielaczyc (2006, 2013) suggests that this framework can be used to both design and analyze technology enabled learning environments. In this work, it was used uniquely for the analysis. However, in this analysis, the framework helped to uncover possible dimensions for further attention in terms of design. As a teacher and a researcher, I find this framework to be succinct and comprehensive in that it addresses the local, social and cultural factors that shape the activities and skills of people (Hatch & Gardner, 1993).

Significance of the Study

Bloomberg and Volpe (2012) remind us that, as opposed to quantitative research with predetermined confidence levels to report significance, qualitative researchers refer to significance as something that is important, meaningful or potentially useful given what we are trying to find out.

van Aaslt and Truong (2011) note that most research connected to knowledge building has been conducted in contexts in which the teachers, and sometimes the students, have had several years of experience in using the knowledge building approach. However, there is little research into how much progress towards knowledge building is possible within a single school year by a teacher and students new to this approach (van Aaslt &Truong, 2011). This action research project contributes to the body of knowledge as it addresses this gap. Knowledge building was an approach new to both my students and to me. This study helps to highlight that, even in a complex and diverse context, progress can be made toward knowledge building, especially in terms of idea diversity, idea improvement, and epistemic agency. Enculturation takes time but progress can be made.

A better understanding is needed of how teachers can bring this approach to knowledge building to life in classrooms (Bielaczyc & Ow, 2014; Chan, 2011). Further, as Scardamalia and Bereiter (2010) have suggested, “There is a wide gap between recognizing the need to increase and democratize innovative capacity and knowing what to do about it” (p. 12). Further, Zhang et al. (2009) recommended, “an ongoing research goal is to further understand the role of the teacher in collectively evolving knowledge-building processes” (p. 38). Bielaczyc and Ow (2014) questioned how educators might develop supportive tools and practices that socialize students into working together as a knowledge-building community and how research deepen our understanding of change processes. The call to better understand the teacher’s role in sponsoring knowledge building was of key interest in this study. This action research begins to elucidate what the work of knowledge building might entail for the student learners and for the teacher, both as learner and as designer for learning. It provides an account of initial design, successes and possible next steps for practice and research.

Increased research interest has surfaced regarding CSCL design for enhanced collective and individual learning in complex classroom settings, with emphasis on both processes and outcomes (Zhao & Chan, 2014). Further, to this, recent studies have suggested that student belief and epistemology are critical factors that influence the work of knowledge building (Bielaczyc, 2006). This work examined whether students, while working in intentionally designed, computer supported, collaborative knowledge-building environments, shifted their personal conceptions of learning and knowing.

Istance (2016) discussed the importance of addressing equity in moving forward for knowledge building. Specifically, he noted that knowledge building must be seen as something not just for the gifted or excellence but for all. I would contend that this action research demonstrates that students in a complex classroom with extremely diverse needs are capable of engaging with the knowledge building principles. In some cases, students who struggled initially with standardized outcomes came to engage more when working with the continual improvement of ideas. This was evident, for example, when looking at written output. Opportunities for knowledge building produced more written output than more standardized assignments. Student time on task also increased when knowledge building, compared to more instances of avoidance during standardized tasks.

Summary

As a teacher-researcher, I entered into this research hoping to better understand knowledge building, specifically what it was and how I might design for knowledge building among the students in my classroom. These hopes were inspired by a desire to improve my own practice and provide my students with opportunity to build deeper understanding of the content.

In this work, I introduced knowledge building to the students by sharing the twelve principles that elucidate knowledge building – real ideas and authentic problems, idea diversity, improvable ideas, rise above, epistemic agency, community knowledge; collective responsibility, symmetric knowledge advance, democratizing knowledge, pervasive knowledge building, constructive use of authoritative sources, knowledge building discourse and embedded, concurrent and transformative assessment. Scaffolds to support students in the work of knowledge building were also introduced and used as prompts both in face-to-face interactions and in the networked environment of Google Applications for Education. These scaffolds included 'My theory is…, I need to understand…, A better theory…, This theory does not explain…, and Putting our knowledge together…' Google Applications for Education was used as a space for sharing and feedback for idea improvement students.

Students were presented with opportunities to work with knowledge building principles and scaffolds using networked technology to share and provide feedback within the context of the grade 4 science curriculum. Further to this, the students were provided with ongoing opportunities to work in other subject areas in ways that would support rather than run counter to the efforts of knowledge building. This included opportunities to work with idea improvement in the area of social studies based on the identified needs for understanding from within the community, along with idea diversity in the writer's workshop and in certain math tasks. This work also involved presenting ongoing opportunities for design thinking to support knowledge building where and when possible.

Over the course of this year-long practitioner action research, I shifted my practice as I began to better understand the concept of knowledge building, the importance of providing opportunities for my students to identify their own unique needs for understanding, and how I might allow my students to work in such a way that they could continue to improve ideas.

In this work, there were students in this classroom who worked on continually improving ideas in different content areas as they began to engage with knowledge building principles. Moreover, students worked increasingly toward idea improvement, especially within the face-to-face environment. Contributions to idea improvement in GAFE shifted in quantity and quality over the year; idea improvement in GAFE remained elusive, perhaps due to limited assessment of contributions on the part the community. Overall, however, working in the way of knowledge building slowly shifted the culture in the classroom, specifically where some students may have started to reconsider their own roles in the classroom, the roles of their peers, the teacher, the role of technology and the activity structures.

In this work, the move toward knowledge building was more successful in some of the content areas over others. For example, for me, as the teacher–researcher, it seemed more feasible to develop theories in the humanities and in science and this, design efforts seemed to focus on these areas more frequently; however, theory generation in mathematics for me, as a teacher, presented more of a challenge. This, in part, may have been potentially due to my own biases, pre-judgments, and previous experiences in mathematics education that resulted in partialities regarding how math should or could be taught. Further, cultural biases and partialities seem to exist on a larger level, whereby math education is often seen as skills, facts and knowledge as outlined in curricular documents. As a possible result of my challenge in seeing opportunities for knowledge building in mathematics and resulting difficulty in designing for knowledge building in math, along with cultural understandings of mathematics on a macro level, students were offered less opportunity to engage in their own theory generation in math. However, recognizing and understanding these partialities on the individual and social level may enlarge possibilities for moving forward for knowledge building.

Overall, it is anticipated that this work will contribute to a larger body of work in providing a narrative of my attempts, as a teacher new to knowledge building, to shift practice so that students might take on the responsibility for the continual improvement of ideas within the classroom community. This work further highlights how my novice efforts impacted students who were also new to knowledge building.

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Appendix A

Observation Protocol

Date

Time

Task Description

Role of the student – What is the student doing or saying? With whom? What does the interaction look like? Sound like?

Role of the teacher - What is the teacher doing or saying? Who are they doing it with?

Role of the technology - What is the technology being used for? Who is using it? Alone or in partners?

Evidence of KB? – Which principles are evident? How do you know?

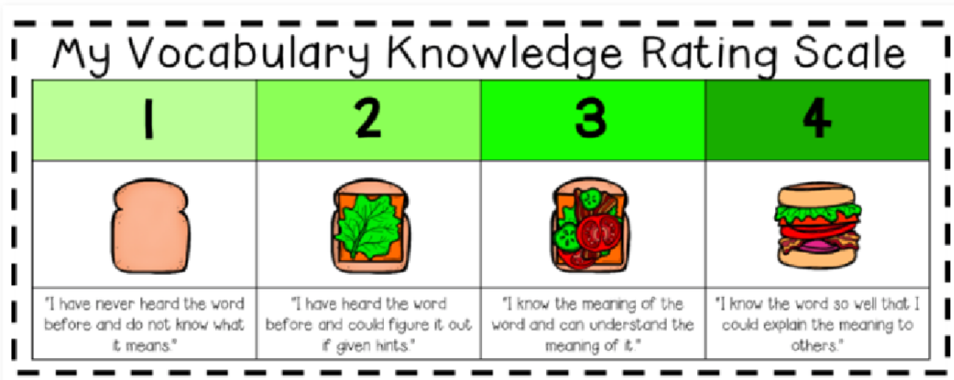
Evidence of Learning? - Which concepts, skills or attitudes are present? How do you know?

Appendix B

Knowledge Rating Vocabulary

Light and Shadow Vocabulary Rating

Name:



	1	2	3	4
sun **light**				

Appendix C

Interview Protocol for Design Thinking

1) What was the problem that you were trying to solve with your design?
2) Can you show me and explain to me how your design works?
3) After you tested this the first time, what ideas did you use to improve your design?
4) If you had time to keep working on this design, what would be your next steps?

Appendix D

Social Infrastructure Framework and Example Questions for Data Analysis

Summary of the Social Infrastructure Framework and Example Questions (Bielaczyc, 2006)		
Dimension	Design Considerations	Example Questions
Cultural Beliefs Dimension	How is learning and knowledge are conceptualized	How should the process of learning be viewed by teachers and students? "What does it mean to know?"
	How students' social identity is understood	How should students view their purpose in the learning environment? How are students meant to view each other-as a learning resources, as team members, as competitors? Are students meant to develop expertise and skills consistent with professionals in the 'real world'?
	How a teacher's social identity is understood	How should teachers view their purpose in the learning environment? How are students meant to view the teacher? Are the teachers meant to be perceived as fellow participants in the learning activities or as directors of the students' activities?
	How the purpose of the tool is viewed	How should the purpose of the tool be viewed by teachers and students? How are students meant to use the tool to carry out the learning objectives? How is the tool meant to fit into the overall workings of the classroom?
Practices Dimension	the activities in which to engage students	Should activity selection left open to students, semi-structured, or tightly sequenced? Should all students carry out the same activities, or should the activities differ according to the needs of the particular students? Should remediation activities be provided if students have difficulties? Should learning the functionality of the tool be a separate activity, or is the tool to be learned in the course of the broader set of activities?

	the associated participant structures of students	How are student group being organized? In what ways are student interactions supported?
	the associated participant structures of teachers	Are the teachers meant to observe or intervene over the course of particular learning activities? What level of control do teachers take over the course of learning? How is teacher control balanced with helping students to learn how to direct their own learning experiences?
	the coordination of on-tool and off-tool activities	What is the relationship between on-tool and off-tool learning activities? Can off-tool and on-tool activities serve to reify concepts in different forms? Can off-tool and on-tool activities provide multiple modes for learning? Are there ways that offline activities can help students to see the generality of what they are learning using the technology-based tool?
Socio-technico-spatial relations Dimension	student–teacher–machine–physical-space configurations	Are the computers located in the classroom or the computer lab? If students are using handhelds or wearable technologies, do they remain with the students, or are they kept in a central location under the control of the teacher? What is the formation of the computers - rows, circular arrangements, wherever there is space in the room? Is there space for students to put learning materials besides machines as they work? Where and what our teachers doing all the students work online?
	student–teacher–cyberspace configurations	Do students work separately or collaboratively in cyberspace? How are student products organized in cyberspace? For example, are they grouped into categories, indexed alphabetically, or randomly arranged? Is online work visible and/or accessible to all? Are teachers meant to get online and use the tool themselves or to shape the online activities by working with students in the offline arena?
	cyberspace–physical-space relations.	What for the trade-offs between using data captured from students physical world as compared to other sources of data? Is it helpful to bring online

		work into off-line forms? What are the affordances of the different means of displaying and interacting with students work?
Interaction with the 'outside world' Dimension	bringing in knowledge from the outside	What sources of outside help might be useful? What is the best way to access such sources? What is needed to make the interaction successful? Is training outside resource people necessary?
	extending the audience for student work	Will be outside audience be active in responding to students work or passive recipients? What types of supports are required?
	interacting with others.	What will be the common activities of the co-collaborators? How will their interactions be structured? Will the technology-based tool itself be used to facilitate the interactions?

Appendix E

Science Exploration Centers – Light and Shadow

<u>Explore #1</u>
Predict what will happen when you shine a light on each cup.

Place the cups in front of the folder. Shine a light on each cup, **observe** what happens, and **sketch** a picture of what happens and/or **record** your **data** in your visual journals.

Materials: Three cups, flashlight, backdrop (file folder)

<u>Explore #2</u>
Fill the cup with water. Place it on a large white piece of paper.
Predict what will happen when you shine a light through the water.

Shine the light though the water from different directions. **Observe** what happens, and **sketch** a picture of what happens and/or **record** your **data** in your visual journals

Materials: Plastic paper, cup, flashlight

<u>Explore #3</u>
Predict what will happen as you move your shadow puppets closer and farther away from the screen.

Try to make some of the shadows. Move your hands away from the screen and close to the screen. **Observe** what happens, and **sketch** a picture of what happens and/or **record** your **data** in your visual journals

Materials: Shadow Puppet images

<u>Explore #4</u>
Predict what will happen if you hold the spoon up in front of your face. What will happen if you flip it over and look in the other side?

Now try it! **Observe** what happens, and **sketch** a picture of what happens and/or **record** your **data** in your visual journals

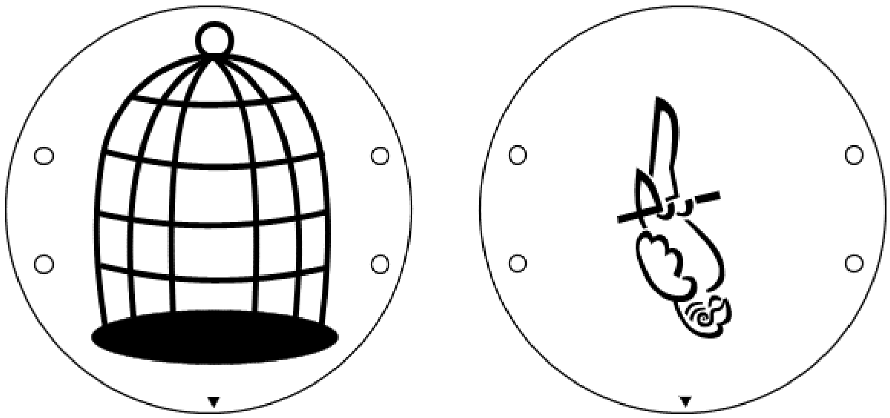
Materials: Spoons

<u>Explore #5</u>
Predict what will happen as you spin the bird and the cage?

Now try it! **Observe** what happens, and **sketch** a picture of what happens and/or **record** your **data** in your visual journals.

Materials: Thaumatrope

Bird in Cage Illusion



Materials:

- 3.5” square piece of lightweight cardboard (an old file folder is perfect)
- String – two pieces, each approximately 3 ft long.
- Copy of bird and cage circles (above)
- Glue
- Scissors
- Hole punch
- Crayons or markers

Instructions:

1) Colour the bird using bright colours.
2) Cut out the two circles (cage and bird)
3) Glue the cage circle to the cardboard.
4) Cut the cardboard to match the circle.
5) Glue the bird circle to the other side of the cardboard.
   ** Line up the small black triangles on the two circles – they should be pointing in the same direction! **
6) Punch four holes as indicated.
7) Thread a piece of string through the two holes on the left side. Tie the ends together to make a loop.
8) Thread the other piece of string through the holes on the right side and make a loop.
9) To see the illusion, hold one loop in each hand, and wind (twist) the strings. Pull the loops apart gently to make the circle spin. Watch the circle as it spins to see the bird in the cage!

Explore #6

Predict what will happen as you look through the glass of water at the pencil.

Now, fill the drinking glass half full with water. Place a pencil in the glass on a slant (like in the picture).

Look at the glass straight on. What do you notice? **Observe** what happens, and **sketch** a picture of what happens and/or **record** your **data** in your visual journals.

Materials: Glasses, pencils

Explore #7

Predict what will happen as you spin the color wheel?

Now try it! Spin the wheel and watch the colors carefully. **Observe** what happens, and **sketch** a picture of what happens and/or **record** your **data** in your visual journals.

Explore #8

1.Use a small piece of tape to attach a penny to the bottom of the bowl.
2.Take a few steps back from the bowl until the penny *just* disappears behind the rim of the bowl
3. Predict what will happen when someone else pours water into the bowl until it is 3⁄4 full.

Now try it! **Observe** what happens, and **sketch** a picture of what happens and/or **record** your **data** in your visual journals.

Materials: Penny, bowl, water

Explore #9

The two arrows are pointed in the same direction. **Predict** what will happen when you hold a glass of water up to the bottom arrow.

Now try it! **Observe** what happens, and **sketch** a picture of what happens and/or **record** your **data** in your visual journals.

Water, cup, paper arrows

Appendix F

Interpretation Outline Tool

Research Question #1
What learning designs enable a class of students to engage in knowledge building?
Hook
Why? What are the other possibilities?

- Makes learning more connected to real world
- Provides novelty
- Sparks curiosity
- Like some topics better than others
- Teacher doesn't understand the relevance of all topics equally well
- Some hooks generated more questions than others
- Hook was not relevant for all students

Consistent use of scaffolds
Why? What are the other possibilities?

- Creates a culture
- Creates structure ie ongoing focus on 'I need to understand'
- Asks kids to work in a way that is consistent within and outside of CSCL
- Helps scaffold thinking
- More emphasis on some scaffolds than others
- GAFE did not support the use of all scaffolds
- Lack of meta-discourse over the use of scaffolds
- Lack of tools built into the technology to support embedded assessment

Technology
Why? What are the other possibilities?

- Motivated by use of tool
- Motivated to choose their own topics
- Liked playing with the features of the tool
- Inspired each other
- Complexity of class
- Time
- Not enough attention given to KB principles
- More attention given to idea improvement over community knowledge or intention
- Too hard to accomplish
- Shifting culture takes time
- Anxiety or 'fear of being wrong' when asked to generate theory
- Distracted by technology

Research Question #2
How do students engage with the knowledge building principles as defined by Scardamalia (2002)?
Students engaged with some over others ie idea diversity, improvement real question
Why? What are the other possibilities?

- More focus on some over others
- Lack of time
- Shift in culture in some ways over others
- Teacher understanding of some more than others
- Student anxiety
- Not enough teacher support
- Too much teacher support
- Lack of attention to some
- Not enough assessment of work to guide practice
- Students don't understand all the principles
- Teacher doesn't understand all principles
- Not enough time given to students to engage with all principles
- Anxiety – students don't want to be wrong

Research Question #3

What is the quality of scaffolded discourse in computer supported collaborative environments?

Chit chat consistently present over year with increasing evidence of idea construction

Why? What are the other possibilities?

- Novelty of tool wore off
- Shift in culture toward purpose of tool
- Students care more about the problem
- Teacher emphasis
- Students increase understanding the affordances of tool
- Not enough assessment embedded
- No exemplars of idea development
- Lack of understanding of criteria for idea improvement
- Not feeling safe enough yet to challenge each other
- Still see ideas as something you own
- Technology itself impedes
- Reading and writing skills limit ability to use computer
- Students did not understand knowledge building well enough to work purposefully with technology

Research Question #4

In what ways can a design thinking approach to education support knowledge building? – Knowledge building can support the continual improvement of ideas

Why? What are the other possibilities?

- Supports a shift in culture around the role of the student and the role of the teacher
- Supports a shift in culture around the students concepts of knowledge and learning
- Supports a shift in community ie seeing each other as resources
- Easy to see that designs need improvement ie need to improve it because it does not function as desired
- Problems from design thinking relevant when hook is authentic
- Hands on and play; 'thinking with your hands'

Appendix G

Copyright Consent Forms

Hi Robin, thank you for getting back and confirming the exact content you were referring to.

Both of those images are fully crown owned and permission to reproduce is granted. This is a one-time, non-exclusive permission for use as outlined in your email below, any other uses will require their own permissions.

The credit lines your provided are acceptable.

Let me know if there is anything further you need. Thank you and good luck with your research project.

[redacted] Alberta Education
Operations and Implementation Support,
Business Support & Resource Authorization Standards
8th Floor, 44 Capital Blvd., 10044 108 Street
Edmonton AB T5J 5E6
[redacted]

From: Robin Parker [[redacted] **Sent:** Tuesday, June 07, 2016 3:39 PM **To:** [redacted] **Subject:** Re: Seeking Copyright Permission

Hi [redacted]

In answer to your questions,
1) yes, i am referring to the puzzle piece.

2) I have attached the image below to which I am referring…

Thank you so much for your help with this; I appreciate your time and efforts.
Robin

[redacted], Intellectual Property Analyst
Alberta Education
8th Floor, 44 Capital Blvd.
10044 – 108 Street NW
Edmonton, Alberta, Canada T5J 5E6

I am writing to you today to request permission to use certain visuals that have been created by
Alberta Education. I am currently a doctoral student with the University of Calgary and am hoping to
engage in an action research project beginning in the fall of 2016 within the public education system.
This work has been prefaced by some of the current initiatives from Alberta Education especially
pertaining to the work in the Inspiring Education document.

I am hoping to use the following images:

Framework for Student Learning in Alberta (Alberta Education, 2011)

Focus on inquiry, Alberta Education (2004)

Please note that I have not modified any of the material, have ensured that the materials are accurate
in their reproduction and have identified Alberta Education as the source of the information using
APA 6 referencing as follows:

Alberta Education. (2004). Focus on inquiry: a teacher's guide to implementing inquiry-based learning.
Retrieved
from https://archive.education.alberta.ca/media/313361/focusoninquiry.pdf
Alberta Education. (2011). Framework for student learning: Competencies for engaged thinkers and
ethical citizens with an entrepreneurial spirit. Retrieved from
https://archive.education.alberta.ca/media/6581166/framework.pdf

Please advise as to next steps and if I am able to use these images in my dissertation. Thank you so
much for your consideration,
Robin Parker

On May 9, 2016, at 8:47 AM, Craig Mertler <[redacted]> wrote:

Hello Robin,

Yes, you may certainly have permission to reproduce the two figures you've listed.

Best of luck with your work, and please let me know if I might be of any assistance.

Thank you,

Dr. Craig A. Mertler

CRAIG A. MERTLER, Ph.D.
Associate Professor
Director, Educational Leadership & Innovation EdD Program
Arizona State University | **Mary Lou Fulton Teachers College**
[redacted] Phoenix, Arizona | [redacted]
Office: [redacted]

From: Robin Parker [redacted]
Date: Friday, May 6, 2016 at 10:53 AM
To: Craig Mertler [redacted]
Subject: Requesting Copyright Permission

I am writing to you today to request permission to use certain visuals that you have published recently. I am currently a doctoral student with the University of Calgary and am hoping to engage in an action research project beginning in the fall of 2016 within the public education system. I am hoping to use the following images in my dissertation to help illustrate the action research process. These visuals are from:

Mertler , C. A. (2014). *Action research: Improving schools and empowering educators (*4th ed.). Los Angeles, CA : Sage

The Process of Action Research

The Process of Action Research, Showing Specific Research Activities in Each Stage

Please note that I have not modified any of the material, have ensured that the materials are accurate in their reproduction and have identified the source of the reference information using APA 6 referencing. Please advise as to next steps and if I am able to use these images in my dissertation.

Thank you so much for your consideration,

Robin Parker