PROMISINGNESS JUDGMENTS AS FACILITATORS OF KNOWLEDGE BUILDING IN ELEMENTARY SCIENCE

by

Bodong Chen

A thesis submitted in conformity with the requirements for the degree of Doctor of Philosophy
Department of Curriculum, Teaching and Learning
Ontario Institute for Studies in Education
University of Toronto

© Copyright 2014 by Bodong Chen
Abstract

Promisingness Judgments as Facilitators of Knowledge Building in Elementary Science

Bodong Chen
Doctor of Philosophy
Department of Curriculum, Teaching and Learning
Ontario Institute for Studies in Education
University of Toronto
2014

Recognizing promising ideas is an important component of expertise and creativity (Bereiter & Scardamalia, 1993; Csikszentmihalyi, 2009; Gardner, 1994). The goal of this research is to explore students’ intuitive understanding of promisingness and to build and test pedagogical and technological supports to enhance promisingness judgments. Toward this end, a “Promising Ideas” tool was developed and continually revised following a design-based research approach involving three cycles of design experiments. The earliest pilot showed students at upper elementary grade levels tended to judge as promising “important facts” as opposed to “ideas with knowledge building potential” in their selections of promising ideas in peer-generated online discourse. A later exploratory study found meaningful socio-cognitive configurations conducive to effective promisingness judgments. With this understanding, in the second design cycle, pedagogical supports were designed around the Promising Ideas tool and subsequently tested in a grade 3 class where students selected promising ideas from their own written online discourse, knowing in advance that selections would influence the direction of their work. After making selections they discussed top highlights across all classmate selections and narrowed their choice to the most promising ideas to serve as the basis for their next knowledge building efforts. In this study, they completed two cycles of this selection process. Qualitative and quantitative results suggest that students as young as 8 years of age
made promisingness judgments that led to greater knowledge advances than same-age students, same topic, more experienced teacher, but without use of the promisingness tool and related discussion. These grade 3 students were able to direct their work in fruitful directions and additionally engage in productive collective decision making. In addition, individual differences among students were revealed and prompted me to explore the linkage of personal epistemic beliefs and promisingness judgments in the third design cycle. With further refined tool and pedagogical supports, the third design cycle engaged a grade 6 class in a similar process of promisingness judgments. Besides confirming knowledge advances in knowledge building work, students’ epistemic beliefs were found co-developing with their knowledge of promisingness and conceptual change. In summary, the thesis explores theoretical issues and implications for future pedagogical and technological developments to facilitate promisingness judgments through collaborative knowledge building.
Dedication

To Zihui, who led me onto this journey. And to Lucas, who gave me sunshine during the final days of this dissertation and will guide Zihui and me to new adventures ahead.
Acknowledgements

I am thankful to many who have supported me in this journey. First and foremost, I would like to express my sincerest gratitude to my supervisor (and also fellow knowledge builder), Dr. Marlene Scardamalia, for her invaluable guidance throughout the years. Watching her tirelessly lifting up all sorts of national and international Knowledge Building initiatives has been truly inspirational for me. It has been a privilege working with her. Her brilliance, energy, dedication, and generosity will keep inspiring me in the future. I would also like to offer my sincere appreciation to my committee: Dr. Carl Bereiter, for always being able to gracefully make complex things simple and “simple” things sophisticated – it has been always great to listen to his thoughts and critical comments; Dr. James D. Slotta, for his generous support, wisdom, and mentorship in various areas – his insights in design and methodology have been especially helpful for this dissertation and his advice on my pursuit of an academic career has been really helpful. Special thanks to Dr. Earl Woodruff and Dr. Jim Hewitt, for their encouragement and valuable comments on my research and for their enjoyable research meetings. I am also grateful to my external examiner, Dr. Carolyn P. Rosé, for offering me a range of insightful ideas to push this work forward.

I am indebted to teachers and principals who have generously supported this work. Their dedication to education and their love for students have been truly special. I am also grateful to students who participated in this study, from whom I have learned a lot, much more than the dissertation has covered for sure.

To my dear IKIT colleagues and friends – Susana La Rosa, Monica Resendes, Chris Teplovs, Maria Chuy, and Alisa Acosta – we had so many enjoyable and memorable moments together, and I would like to thank you for your help and friendship through the years. Special thanks to Jianwei for accommodating my research projects and offering invaluable advice on various matters, and to Huang-Yao, for our Second Cup coffee time every time he visited Toronto and for your gracious guidance. I would also like to

v
acknowledge Julia Pan, Stian Håklev, and Naxin Zhao, who helped to make my journey at OISE a great one.

Finally, my heartfelt thanks to my parents, who have been tirelessly cheering for me during the past twenty eight years; to my wife Zihui, who has been a hero to me in so many different ways; and to our 3-month-old baby, Lucas, for his big smiles, funny poses, and philosophical looks – I very much look forward to the knowledge building journey with him ahead.

To everyone, thank you.

Bodong Chen
Quebec City
# Contents

## 1 Introduction

1.1 Motivation for the Study ........................................... 1  
  1.1.1 The Knowledge Building Approach .......................... 4  
  1.1.2 A New Competency for Knowledge Creation ............... 6  
1.2 Research Goals .................................................. 8  
1.3 Organization of the Dissertation ............................... 8  

## 2 Background and Issues

2.1 Chapter Overview .................................................. 10  
2.2 Theoretical Foundations ......................................... 11  
  2.2.1 Expertise ..................................................... 11  
  2.2.2 Constructivism .............................................. 19  
2.3 Knowledge Building .............................................. 24  
  2.3.1 Deep Constructivism and Collective Cognitive Responsibility 24  
  2.3.2 Design Thinking in Theory Building ........................ 28  
  2.3.3 Epistemological Framework of Knowledge Building ....... 31  
  2.3.4 Knowledge Building Pedagogy .............................. 33  
  2.3.5 Knowledge Building Environments, Knowledge Forum ....... 36  
  2.3.6 Application of Knowledge Building in Science Education 41  
  2.3.7 Summary ..................................................... 48
2.4 Towards an Understanding of Promisingness

2.4.1 Why Is Promisingness Important in Knowledge Building?

2.4.2 Making Sense of Promisingness

2.4.3 Promisingness in Creative Processes

2.4.4 Psychological Accounts of Promisingness Judgments

2.4.5 To Situate Promisingness in Education

2.4.6 Summary

2.5 Tool Support for Promisingness

2.6 Research Questions

3 Methodology

3.1 Chapter Overview

3.2 Design-Based Research

3.3 Overview of Research Plan

3.3.1 Elements of Design

3.3.2 Overview of Design Cycles

3.4 Research Settings

3.4.1 Research Sites

3.4.2 Participants

3.5 Methods, Data Sources, and Analytic Approach

4 Study 1: Exploratory Research to Elicit Promisingness

4.1 Chapter Overview

4.2 Methods and Analyses

4.2.1 Participants

4.2.2 Materials

4.2.3 Design and Procedures

4.2.4 Data Sources
4.2.5 Data Analyses ................................................................. 108

4.3 Pilot A: To Find the Most Promising Ideas ................................. 112
  4.3.1 Classroom and Knowledge Forum Activities .............................. 112
  4.3.2 The Epistemic Nature of Identified Promising Ideas ..................... 119
  4.3.3 Were Student Judgments of Promisingness Based on Structural
        Complexity of Ideas? ............................................................... 124
  4.3.4 Summary of Results ............................................................. 125

4.4 Pilot B: To Set Up a Workspace for the Next Year’s Class ................. 126
  4.4.1 Classroom and Knowledge Forum Activities .............................. 126
  4.4.2 Ideas Identified by Students .................................................. 133
  4.4.3 The Epistemic Nature of Identified Promising Ideas ..................... 135
  4.4.4 Did Student Assessments Correspond with the Judgment of
        Someone with More Subject-Matter Knowledge? .......................... 135
  4.4.5 Were Students Inclined to Highlight Their Own Ideas? ................ 136
  4.4.6 Relationship between Promisingness Judgment Performance and
        Content Knowledge ................................................................. 137

4.5 Discussion .................................................................................. 141
  4.5.1 Major Research Findings in Two Pilots ................................. 141
  4.5.2 Lessons Learned from the Exploratory Study............................... 141

4.6 Chapter Summary ................................................................. 143

5 Study 2: Promisingness Judgments with Principle-Based Pedagogical
        Supports ................................................................................. 144
  5.1 Chapter Overview ................................................................. 144
  5.2 Methods and Analyses ............................................................. 145
    5.2.1 Participants ................................................................. 145
    5.2.2 Technological Supports for Promisingness ................................. 146
    5.2.3 Pedagogical Supports for Promisingness ................................. 148
List of Tables

3.1 Comparisons of Psychological Experiment Methods and Design-Based Research Methods ........................................ 83
3.2 An Overview of Research Sites and Participants ......................... 92
3.3 Overview of Data Sources and Analytic Approaches .................. 97

4.1 Comparisons of Design in Pilot A and B .......................... 106
4.2 An Overview of Analyses, Questions, and Reliability Measures .... 109
4.3 Ways ofContributing to Knowledge-Building Discourse .......... 110
4.4 Structure of the Observed Learning Outcome (SOLO) Taxonomy .... 111
4.5 Examples of Identified Ideas Coded Under the Theorizing Category 121
4.6 Examples of Identified Ideas Coded Under the Questioning Category 122
4.7 Examples of Identified Ideas Coded Under the Facts/Evidence Category . 123
4.8 Correlations Between Promisingness Judgment and Content Knowledge 140

5.1 An Overview of Data in Study 2 .................................. 155
5.2 An Overview of Data Analyses in Study 2 ............................ 157
5.3 Facets of Student Initial Conceptions of Promisingness ............ 169
5.4 Measures of Social Networks in the Experimental Class ............ 183
5.5 Group × Phase Factorial Analysis of Variance for Scientificness .... 188

6.1 An Overview of Knowledge Forum Dataset .......................... 213
6.2 Coding Categories of Depth of Questioning and Ways of Justification . 214
6.3 Coding Schemes for Promisingness Judgments . . . . . . . . . . . . . . . . . 215
6.4 Facets of Student Conceptions of Promisingness . . . . . . . . . . . . . . 222
6.5 Improvement of Promisingness Judgment Performance . . . . . . . . . . . 224

7.1 Mapping Promisingness Judgments with Knowledge Building Principles . 244
# List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>A Knowledge Forum note.</td>
<td>38</td>
</tr>
<tr>
<td>2.2</td>
<td>A Knowledge Forum view.</td>
<td>38</td>
</tr>
<tr>
<td>2.3</td>
<td>Darwin’s tree of life.</td>
<td>55</td>
</tr>
<tr>
<td>2.4</td>
<td>Discourse.org: A new discussion forum software.</td>
<td>74</td>
</tr>
<tr>
<td>4.1</td>
<td>Highlighting functionalities of the Promising Ideas tool, version 1.</td>
<td>101</td>
</tr>
<tr>
<td>4.2</td>
<td>Highlighting ideas with PI, version 1.</td>
<td>102</td>
</tr>
<tr>
<td>4.3</td>
<td>Idea aggregation window in PI, version 1.</td>
<td>104</td>
</tr>
<tr>
<td>4.4</td>
<td>Customized color scheme in PI for Pilot B.</td>
<td>107</td>
</tr>
<tr>
<td>4.5</td>
<td>“Grade Four Rocks and Minerals” view assessed in Pilot A.</td>
<td>114</td>
</tr>
<tr>
<td>4.6</td>
<td>The distribution of numbers of ideas highlighted by students in Pilot A.</td>
<td>115</td>
</tr>
<tr>
<td>4.7</td>
<td>The distribution of numbers of hits of identified ideas in Pilot A.</td>
<td>116</td>
</tr>
<tr>
<td>4.8</td>
<td>The epistemic nature of highlighted promising ideas in Pilot A.</td>
<td>120</td>
</tr>
<tr>
<td>4.9</td>
<td>An example of factual contributions highlighted as promising in Pilot A.</td>
<td>123</td>
</tr>
<tr>
<td>4.10</td>
<td>Distribution of structural complexity of theorizing contributions in Pilot A.</td>
<td>125</td>
</tr>
<tr>
<td>4.11</td>
<td>The Grade 5/6 Electricity view evaluated in Pilot B.</td>
<td>127</td>
</tr>
<tr>
<td>4.12</td>
<td>Idea aggregation list produced by students in Pilot B.</td>
<td>131</td>
</tr>
<tr>
<td>4.13</td>
<td>Notes with ideas of different types highlighted within.</td>
<td>132</td>
</tr>
<tr>
<td>4.14</td>
<td>Distribution of numbers of ideas highlighted by students in Pilot B.</td>
<td>134</td>
</tr>
<tr>
<td>4.15</td>
<td>Distribution of identified ideas across idea types in Pilot B.</td>
<td>134</td>
</tr>
<tr>
<td>4.16</td>
<td>“Expert” rating of promisingness judgments in each idea type.</td>
<td>136</td>
</tr>
</tbody>
</table>
4.17 Contingency table of idea highlighting behavior among students in Pilot B. 138

4.18 Visualization of social network based on idea highlighting in Pilot B. . . 139

5.1 Export selected ideas to a new view, with PI version 2. . . . . . . . . . . 147

5.2 Procedures in the experimental class in Study 2. . . . . . . . . . . . . . . 152

5.3 A note with one promising idea highlighted within. . . . . . . . . . . . . 153

5.4 The idea aggregation window listing the top three ideas highlighted by
Grade 3 students in Study 2. . . . . . . . . . . . . . . . . . . . . . . . . . . . 154

5.5 The classroom environment setting for promisingness discussion in Grade 3. 164

5.6 The epistemic nature of highlighted promising ideas in Study 2. . . . . . 172

5.7 Inquiry thread 1, from the comparison class in Study 2. . . . . . . . . . . 179

5.8 Inquiry thread 2, from the experimental class in Study 2. . . . . . . . . . 180

5.9 Building-on and idea-highlighting networks in Phase 1 and 2 in the exper-
imental class. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 185

5.10 Change of scientificness of ideas in the experimental and comparison class. 188

5.11 Results of Latent Semantic Analysis comparing community knowledge in
both the experimental and comparison classes with authoritative sources. 189

6.1 Highlight an idea with PI version 3 in Knowledge Forum. . . . . . . . . . 203

6.2 Visual cues of promising ideas, unsolved problems, and useful facts in a
Knowledge Forum view, enabled by PI version 3. . . . . . . . . . . . . . . 204

6.3 Idea aggregation window with a new criteria filter, provided in PI version 3.205

6.4 A synthesis note created based on identified promising ideas. . . . . . . 206

6.5 A note with a promising idea highlighted within. . . . . . . . . . . . . . 206

6.6 Procedures in the experimental class in Study 3. . . . . . . . . . . . . . . 210

6.7 CORDTRA visualization of content analysis results. . . . . . . . . . . . . 225

6.8 Improvement of epistemic beliefs from pre to post-test in Study 3. . . . 228
6.9 Improvement of epistemic beliefs in the certainty dimension from pre to post-test. ................................................. 229

7.1 A model of knowledge-creating dialogue. ................................................. 238

7.2 The map layout of idea aggregation window. ......................................... 246
Chapter 1

Introduction

Recognizing promisingness—the virtue of “being promising” in a creative context—is an important element of expertise and creativity (Bereiter & Scardamalia, 1993; Csikszentmihalyi, 2009; Gardner, 1994). This dissertation reports a research study that investigated the concept of promisingness within the educational context of knowledge building. Aided by theoretical efforts to articulate this concept, this dissertation centers on design, implementation and evaluation of knowledge practices and technological supports to engage students in making meaningful promisingness judgments in their knowledge building endeavors. This chapter begins with a discussion of the motivation for this study, exploring issues and ideas that led me to the investigation of promisingness. This discussion is followed with an overview of research goals and concludes with a description of the organization of this dissertation.

1.1 Motivation for the Study

Innovation and invention are needed to solve complex problems emerging in various societal areas, to fill critical “ingenuity gaps” between the lack of methods available to address them and the supply of usable ideas (Homer-Dixon, 2000). This need for innovation and production of new knowledge is becoming increasingly evident in many
sectors of the “knowledge age” or “innovation-driven societies” (Drucker, 1994; OECD, 2000). However, innovation cannot be adequately achieved by sparks of “creative” ideas or simple combinations of them. It normally requires complex social configurations that provide “liquid networks” for ideas to find their “adjacent possibles” to develop into something significant (S. Johnson, 2010). To make the critical progression from idea to innovation, problem solvers need to go through a sometimes long constructive process involving a series of choices made under conditions of uncertainty (Fahrenheit 212, 2010).

Contemporary school education, unfortunately, tends to ignore this reality. Although an important goal in education is to help students to develop capabilities needed for solving complex future problems, current school models are not configured in a way to nurture new competencies important for doing this. Specifically, in contrast to the extent of complexity people face in innovative circumstances, school education is typically characterized by well-structured problems of relatively short duration and with fixed goals. In a typical classroom, students rarely gain any experience dealing with risks, uncertainty, choice-making, long-stretches of work, and real-world problem-solving. It becomes questionable whether our school practice is doing justice to the goal of developing knowledge-creating talents, as well as to achieving students’ knowledge-creating potential. Thus, to help build a citizenry attuned to the conditions of life in the knowledge or innovation-driven society, attention needs to be given to new areas of research that explore students’ capability in dealing with complex, ill-defined problems.

Related to this issue, prior educational research has highlighted the importance of exposing students to complexity and struggle in the process of learning. For example, VanLehn and colleagues (2003) find successful learning in physics requires the student to reach an impasse before instructional structure is provided. Similarly, Kapur’s (2008) “productive failure” research shows that letting students explore—and more importantly fail—in solving ill-structured mathematics problems before instruction results in better performance. By delaying the structure, students avoid “lock-in” of direct instruction and
get the chance to generate conceptions, representations and understanding that expose them to higher levels of complexity in the problem space (see also, Kapur & Bielaczyc, 2012). Student learning could in turn potentially become more adaptive and flexible (Kauffman, 1996). Such “latent productivity” of impasses and failures shown in those studies can be explained by the notion of negative knowledge, which is about knowing what kinds of errors to avoid (Bickhard & Campbell, 1996). In productive failure studies, for instance, those students experiencing failures would have a better chance to develop negative knowledge which helped them perform better in subsequent problem-solving. As Bickhard and Campbell (1996) articulate, knowing what errors to avoid is more crucial in the long run than knowing what is correct at a moment, i.e., positive knowledge. “Positive knowledge gets replaced when failing the tests imposed by new negative knowledge, while in contrast negative knowledge persists and provides a framework for positive knowledge to develop and get organized” (p. 410). Overall, these studies of impasses in learning identify a promising line of “negative knowledge” inquiry that raises attention to failures and errors that are usually not explicitly incorporated—or even intentionally avoided—in traditional education. These studies reveal new possibilities of teaching for complex problem-solving and deep understanding.

In building education for knowledge creation, however, the studies of impasses and failures still fall short in addressing several vital issues. First, ill-structured problems as explored in Kapur’s (2008) study were designed for teaching specific principles in one subject. In contrast, real-world complex problems usually go across several subject domains; to solve them considerable effort is needed to study related complex situations and to make decisions on which direction to follow. As a result, the latent productivity of failures found in these studies of one single domain may not transfer to real-world situations. Second, although the students in these studies could face uncertainty about which solution path to take, the goal is usually fixed or not subject to adjustment, whereas in real-world complex problem solving the goal frequently evolves along with steps toward
solution. Finally, because these ill-structured problems were adapted to a typical lesson-based instruction context, the time students spent on each problem was usually limited to a single class session. As a result, although students could be confronted with failures or impasses, they seldom experience the long stretches of work with no clear feedback, which are very typical in real-world problem solving.

To prepare students for knowledge creation, we need to go further than merely exposing students to failures and engage them in solving real-world complex problems in a way that could maximize their capability in solving such problems in the future. The Knowledge Building approach, developed by Bereiter and Scardamalia (1993) based on decades of research on expertise, represents an alternative to set education onto this path. It aims to engage learners in genuine knowledge creation appropriate to their existing competencies and move them to higher levels through engagement in knowledge building communities.

1.1.1 The Knowledge Building Approach

As a social constructivist theory and pedagogy, Knowledge Building aims to refashion education fundamentally so that it becomes a coherent component of the current knowledge-creating civilization (Scardamalia & Bereiter, 2006). It extends from the concept of intentional learning, which was used by Bereiter and Scardamalia (1993) to describe characteristics of expertise. Experts capable of intentional learning have three distinguishing features: (a) knowing the limits of understanding and skills of one’s fields, (b) engaging in “progressive problem-solving” by continually reinvesting freed-up information processing capacity in new learning, and (c) focusing on the goal of advancing the field. Based on this understanding, Bereiter and Scardamalia argue that education should engage students in intentional learning so that they become expertlike learners and eventually experts. To facilitate this goal, Computer Supported Intentional Learning Environment (CSILE) was implemented in early 1980s to provide a technological envi-
Student work in networked environments made clear the powerful social processes that needed to be addressed, leading in the early 1990’s to focus on knowledge building communities. In line with this change CSILE was reengineered as Knowledge Forum. Bereiter and Scardamalia (2014) have recently elaborated parallels between this work and developments in the organizational sciences. In an article titled “Knowledge Building and Knowledge Creation: One Concept, Two Hills to Climb” they indicate that the terms “knowledge building” and “knowledge creation” entered into the literature at about the same time—the former in the learning sciences (Scardamalia & Bereiter, 1991; Scardamalia, Bereiter, & Lamon, 1994), the latter in the organizational sciences (Nonaka, 1991; Nonaka & Takeuchi, 1995). It has taken a long time, however, for these concepts to be seen as synonyms, mostly because of the dominant belief that students learn, they do not create knowledge. Thus a plausibility barrier has obscured the parallels.

Knowledge building as applied to education regards students as legitimate contributors to knowledge creation in society and aims to engage them in “the full process of knowledge creation from an early age” (Scardamalia & Bereiter, 2003). Knowledge creation is the focus, learning an demonstrable “by-product” of knowledge building. The emphasis on building new knowledge requires students to assume cognitive responsibility that is otherwise taken by the teacher or instructional designers. As epistemic agents, students in knowledge building need to identify problems of understanding, establish and refine goals, gather information, theorize, design experiments, build models, and monitor and evaluate progress, all directed by the participants themselves toward knowledge building goals (Scardamalia & Bereiter, 2003). These cognitive responsibilities are collectively taken by a community of students, so that “the condition in which responsibility for the success of a group effort is distributed across all the members rather than being concentrated in the leader” (Scardamalia, 2002, p. 68).
In knowledge building, one important aspect of cognitive responsibility is to know the limits of current community understanding and find promising directions for tackling these limits. In order to advance collective knowledge, knowledge builders need to recognize the frontiers of their knowledge. This is not something students doing a pre-defined project are likely to do, but it is of special significance to anyone undertaking creative endeavors. This aspect of knowledge building or knowledge creation is captured by the concept of promisingness. Promisingness is vital for knowledge building in that it guides actions in long-stretches of work from nascent ideas to innovation; it is argued to be an important step in knowledge creation (Gardner, 1994), and to distinguish experts from non-experts (Bereiter, 2002b; Bereiter & Scardamalia, 1993).

Regardless of its importance for knowledge building, promisingness is yet to be empirically studied. In the educational context, it is not even clear whether young students could actually make promisingness judgments for the sake of collective knowledge advancement. This dissertation strives to extend current knowledge building research by explicitly incorporating promisingness as an important component of knowledge-building practices.

1.1.2 A New Competency for Knowledge Creation

Besides the pursuit of pedagogical approaches for knowledge creation, the rise of knowledge society also leads to rethinking of competencies important for the new age. With “ideas and knowledge functioning as commodities” (R. E. Anderson, 2008, p. 5), competencies dominant in the industrial era have become less important while competencies for knowledge production are in high demand (Levy & Murnane, 2004). One of the most significant efforts to tackle this issue is the “21st Century Skills” movement, brought together by a number of governments, business, and international initiatives in the past decade or so. This movement has garnered extensive attention that goes beyond general efforts to improve education in various subjects. Among these initiatives, the Partner-
ship for 21st Century Skills (2009) is promoting the adoption of standards for knowledge and skills that are believed essential for 21st century citizenship. Their framework, composed of “Core Subjects and 21st Century Themes,” “Learning and Innovation Skills,” “Information, Media and Technology Skills,” and “Life and Career Skills,” has been implemented worldwide to help practitioners integrate skills into the teaching of core academic subjects. This approach of defining lists of skills based on conventional wisdom is shared among other 21st century skills initiatives (e.g. Binkley et al., 2012).

Scardamalia, Bransford, Kozma, and Quellmalz (2012) argue that the skills-oriented approach needs to be bolstered by a complementary approach focused on the emergence of new competencies. This is especially important at the time when young people are being educated for jobs that do not yet exist (Fisch & McLeod, 2009). Compared to popular lists of 21st Century skills, several more specific competencies anchored in empirical research; such competencies include systems thinking (Wilensky & Resnick, 1999), abductive reasoning (Paavola, 2004), analogical thinking (Dunbar, 1995; Holyoak & Thagard, 1997), and ability to work with abstractions (Bereiter & Scardamalia, 2003, 2006). Of growing significance is transliteracy (Liu, 2011)—the ability to create coherence out of fragments. Although these competencies have not become household terms like “21st century skills,” promising research initiatives have been created to foster them in school settings. Therefore, to cultivate knowledge creation talents, more efforts are needed to elicit important competencies from current understanding of knowledge creation and explore ways to foster them among students. The capability of recognizing promisingness, a competency deemed important by expertise and creativity literature, could be among these competencies—competencies currently underrepresented, if indeed represented at all, in the 21st century skills movement. This thesis represents an effort to investigate whether promisingness might be introduced to students and to determine the extent to which it might have significant impact on students’ knowledge building. The work builds on previous knowledge building research that has revealed compelling capabilities for the-
ory building in young children (Scardamalia & Bereiter, 2006; Scardamalia & Egnatoff, 2010). In similar manner this research attempts to uncover new competencies through enriched knowledge building environments for promisingness judgments.

1.2 Research Goals

The dissertation explores classroom innovations to cultivate students’ capability of recognizing promisingness in the context of knowledge building. It is the first direct empirical investigation of promisingness in knowledge building, including technical support for promisingness judgments and analysis of knowledge-building discourse focused on promisingness. It reports explorations of engaging students in the practice of identifying promising ideas in knowledge building and its impact on students’ collective idea improvement. The main goals of the dissertation are:

- To understand elementary school students’ intuitive understanding of promisingness in the context of knowledge building
- To explore knowledge practices to facilitate promisingness judgments
- To develop technological supports to facilitate students’ understanding of promisingness in knowledge building and evaluation of promisingness of their ideas
- To investigate the impact of promisingness judgments carried out by students on various aspects of knowledge building
- To explore linages between the knowledge of promisingness and students’ meta-level understanding, such as epistemic beliefs

1.3 Organization of the Dissertation

This dissertation is composed of seven chapters. In Chapter 2, I present a conceptual discussion of promisingness, reviewing theoretical underpinning of this concept and rele-
vant knowledge building literature. I also review literature on promisingness judgments in various domains and attempt to connect it to relevant educational literature. This review is followed by an overview of methodology in Chapter 3, focusing on design-based research, research settings, participants, and general framework of data analysis. After that, in Chapter 4 I report two pilot studies exploring two different experimental settings to encourage promisingness on the part of students in the elementary school years. Following the lessons learned from these pilot studies, Chapter 5 introduces the first design cycle of socio-technological supports for promisingness judgments. Detailed methods, analysis, and findings are presented, focusing on the impact of promisingness judgments on knowledge-building discourse. Oriented towards future research agenda, Chapter 6 presents another design cycle exploring the linkages between promisingness and epistemic beliefs. Implications of this dissertation are discussed in the final chapter.
Chapter 2

Background and Issues

2.1 Chapter Overview

In this chapter I review research relevant to promisingness, drawing from literature on expertise, cognitive science, learning theories, and the history of science. The goal of this review is to develop a clearer understanding of promisingness, especially in the context of knowledge building. This chapter is organized as follows. In Section 2.2, I present two theoretical underpinnings of the present dissertation research—expertise and social constructivism—which are also foundations of knowledge building. This section is followed by a selective review of knowledge building literature in Section 2.3, highlighting important aspects of knowledge building epistemology, theory, and pedagogy that are related to promisingness. In Section 2.4, I present a more in-depth analysis of promisingness, integrating insights from a broader range of literature. In Section 2.5, I discuss challenges in current knowledge building environments for supporting promisingness and present potential solutions to address these challenges. Finally, I present key research questions I have tackled in this dissertation research in Section 2.6.
2.2 Theoretical Foundations

This dissertation research is rooted in expertise research and social constructivism perspectives, as is knowledge building—the context in which this research is conducted. I review key points of these two theoretical foundations at the beginning of this dissertation, to provide scientific foundation for promisingness.

2.2.1 Expertise

Research on expertise, which includes defining expertise and comparing expert and novice performance, has important implications for advancing the science of learning. The study of expertise provides valuable insights into the nature of experts’ thinking, problem-solving, and ultimately illustrates the results of successful learning. This area of research is mainly concerned with what constitutes expertise and how experts differ from novices. One key message from decades of research is that “it is not simply general abilities, such as memory or intelligence, nor the use of general strategies that differentiate experts from novices; instead, experts have acquired extensive knowledge that affects what they notice and how they organize, represent, and interpret information in their environment” (Bransford, Brown, & Cocking, 2000, p. 31). Hence, it would be beneficial to consider these aspects of expert knowledge and expert ways of knowing when we are discussing education for successful learning.

Knowledge of promisingness, which is the major concern of this dissertation, represents one type of expert knowledge and one essential component of expertise (Bereiter & Scardamalia, 1993). In this section I review three interconnected dimensions of expertise, including the capacity of recognizing patterns, tacit knowledge, and adaptive and creative expertise, to situate the present research of promisingness in the long-standing line of expertise research.
Recognizing Meaningful Patterns in Information

Experts demonstrate superior capability in recognizing meaningful patterns of information. In one of the earliest studies of expertise, de Groot (1965) investigated how world-class chess masters could consistently outperform their opponents. In a think-aloud protocol, chess masters and chess players with good skills but less experienced were both shown examples of chess games and were asked to think aloud as if they were playing as one of the players. Results did not find any gross differences in thought processes, including the number of moves considered, search heuristics, and depth of search. Rather, masters were very good at coming up with the “right” moves for further consideration, whereas weaker players spent considerable time analyzing the consequences of bad moves. Masters appeared to be more capable of identifying the most promising moves rather than out-thinking others in terms of general play strategies. De Groot attributed this ability of chess masters to their superior capacity in recognizing meaningful chess configurations and thereafter quickly recovering the strategic implications of these situations. This advantage allowed them to consider sets of possible moves that were superior to, or more promising than, others.

Chess masters’ capability in recognizing meaningful patterns is based on their rich experience of chess play. As de Groot (1965) noted:

> We know that increasing experience and knowledge in a specific field (chess, for instance) has the effect that things (properties, etc.) which, at earlier stages, had to be abstracted, or even inferred are apt to be immediately perceived at later stages. To a rather large extent, abstraction is replaced by perception, but we do not know much about how this works, nor where the borderline lies. As an effect of this replacement, a so-called ‘given’ problem situation is not really given since it is seen differently by an expert than it is perceived by an inexperienced person. (pp. 33-34)

According to this point of view, patterns in chess configurations seemed readily apparent to the masters because of their rich experience. Enabled by more advanced chunking strategies (Chase & Simon, 1973) and/or long-term memory templates (Gobet & Simon,
Chapter 2. Background and Issues

1996), chess masters could reduce abstraction and inference in chess play into perception of meaningful patterns. This sets them on a much superior trajectory of solving problems. Masters are better directly “perceiving” promising moves so they need only focus limited cognitive resources on these moves.

Criticizing the traditional dichotomy of declarative and procedural knowledge, Bereiter (2002a) attributed such chess masters’ superior capacity in pattern recognition to a special type of knowledge—impressionistic knowledge—a body of knowledge based on an individual’s impressions, feelings, and emotion accumulated from his/her experience. Although this type of knowledge is not treated as “knowledge” by traditional knowledge taxonomies per se, it has been proven to inspire actions in a sound way in many different settings. Taking chess play for example, impressionistic knowledge gained from chess masters’ rich experience enables them to recognize or, in de Groot’s words, perceive meaningful patterns effortlessly, whereas lower-ranked players rely more on abstraction and inference.

Identifying “good” moves in chess play based on pattern recognition represents one interesting example of promisingness judgments by experts. Such evaluation of promisingness has also been brought up in other areas of expertise. In their study of expert writers, Bereiter and Scardamalia (1993) found that expert writers constantly evaluated possible directions as their writing unfolded. This evaluation was based on promisingness pattern recognition that involved at least three aspects: (1) direct match to goal, (2) match to capabilities of the person, and (3) pointers to further possibilities. These aspects are bundled into specific schemas, which are akin to chess masters’ discrimination nets or templates for identifying good moves (Gobet, 1998). For example, an expert writer’s capability of developing characters could be attributed to “a promising character schema that contains knowledge about: what makes a character appealing to readers; what makes a character easy and rewarding to write about; and what constitute pointers to other promisingness schemas such as promising plot and promising theme.
schemas” (Bereiter & Scardamalia, 1993, p. 137). According to their point of view, the idea of schema-based promisingness recognition can be extended to other contexts such as a promising question schema for creative scientists or a promising painting schema for artists. The key message here is that expert writers have superior capability in recognizing patterns—in this case, promisingness patterns—based on their rich prior knowledge and experience.

Pattern recognition concerning the direction of “moves” is also evident in scientific activities. When explaining the creative process, Gardner (1994) raised attention to the step of recognizing one element or idea as discrepant when working in a scientific domain. He wrote:

Now, of course you have to recognize the element as discrepant; a number of our retrospective accounts show that the discrepancy may have been around a while but people did not take it seriously. The thinker has an intuition, what the Gestalt psychologist called a “Vorgestalt.” There is something pregnant about discrepant elements, something that makes them stand out. Today, I use the word “promisingness.” Often this discrepancy encourages the individual to cast around (to use a phrase that Andrew Huxley used) for ideas on how to deal with that discrepant element. (p. 267)

According to Gardner’s perspectives, this step of recognizing discrepancy is important for scientists because it encourages them to further invest effort to find ways in dealing with identified discrepant elements. Although it is usually not until the final breakthroughs when the richness of the discrepancy becomes manifested, having such a sense of promisingness is very helpful at the time when principled knowledge around the problem is scarce (Bereiter, 2009). This capacity in recognizing promisingness is strong for some scientists, especially those with years of experience working in a domain.

In summary, pattern recognition abounds in expert thinking and problem solving, especially involving judgments regarding next moves. Promisingness evaluation has been recognized as one important aspect of thinking in experts’ pattern recognition and a distinguishing feature of expertise (Bereiter & Scardamalia, 1993). Exploring innovations that promote students’ capacity of making promisingness judgments could be fruitful.
Tacit knowledge

The term tacit knowledge was first introduced by Polyani (1966) to describe the notion that “we can know more than we can tell;” not all knowledge can be adequately articulated verbally. The ability to recognize patterns in complex situations is sometimes thought to be based on tacit knowledge. In the case of expertise, Dreyfus and Dreyfus (2005) suggested:

If one asks an expert for the rules he or she is using, one will, in effect, force the expert to regress to the level of a beginner and state the rules learned in school. Thus, instead of using rules they no longer remember, as knowledge engineers suppose, the expert is forced to remember rules they no longer use... No amount of rules and facts can capture the knowledge an expert has when he or she has stored experience of the actual outcomes of tens of thousands of situations. (p. 788)

Experts are generally believed to have rich sources of knowledge that are tacit. It figures as perception by aforementioned chess masters (de Groot, 1965), or the inexplicable sense of discrepancy by scientists working on the frontiers of their fields (Gardner, 1994). Taking the field of medicine for another example, there has been a heated debate between two camps that respectively advocate an evidenced-based model of medicine (e.g. Guyatt, Rennie, Hayward, et al., 2002) and a tacit dimension of knowledge. Studies of medical experts have demonstrated that clinical diagnoses usually involve a considerable amount of tacit knowledge beyond scientific reasoning (Patel, Arocha, & Kaufman, 1999). It has been argued that tacit knowledge—the inarticulate aspects of knowledge that can only be acquired via direct experience—is as important as, or in some cases, even more important than explicit knowledge for solving real-world problems such as diagnosing a medical condition. Thus, medical training should raise attention to knowledge in implicit forms because clinical knowledge must be experienced and embodied in real-world practice (Heiberg Engel, 2008; G. Norman, Young, & Brooks, 2007).

Coming from an organizational perspective, Nokaka and colleagues have highlighted the importance of tacit knowledge in a knowledge-creating organization (Nonaka, 1991;
Nonaka & Toyama, 2003; Nonaka & von Krogh, 2009; Von Krogh, Ichijo, & Nonaka, 2000). Building upon Polanyi’s original view of tacit knowledge, Nonaka (1991, 1994) depicted a spiral model of knowledge featuring conversions between tacit knowledge and explicit knowledge. When an expert is able to articulate the foundations of his/her tacit knowledge, explicit knowledge is created and can be subsequently shared within the organization. On the other hand, as new explicit knowledge is shared throughout an organization, other members could internalize it and develop it into new tacit knowledge of their own. A new round of conversion could start again, but at a higher level. Through such a spiral of knowledge, the organization’s knowledge base could keep growing. Thus, a knowledge-creating organization should nurture conditions for articulation of tacit knowledge and internalization of explicit knowledge.

The idea of cycles of knowledge conversion between tacit and explicit knowledge is aligned with the notion of “team expertise,” which highlights that expertise operates in a team or organizational context, extending beyond the realm of individual participants (Bereiter & Scardamalia, 1993). Decision-making for medicine, for example, is usually a collective process (Patel et al., 1999), so the tacit dimension of expert knowledge also needs to be understood from a collective perspective. These insights have informed thinking of organizational learning and development of collective learning to increase regional innovative capacity (A. Lam, 2000; Lawson & Lorenz, 1999).

The knowledge of promisingness discussed above represents one type of tacit knowledge because the process of identifying promisingness is usually inarticulate and not explicitly raised to be a concern in most contexts (Bereiter & Scardamalia, 1993). Previous research on tacit knowledge is based on the assumption that tacit knowledge develops through implicit learning (Eraut, 2000; Patterson, Pierce, Bell, & Klein, 2010; Reber, 1989). Following Nonaka’s (1991) knowledge conversion model, it would be promising to develop explicit means to foster the tacit knowledge of promisingness within a knowledge-creating organization or community.
Adaptive and Creative Expertise

Previous research on expertise has distinguished two very different types of expertise: one that is relatively routinized and one that is flexible and more adaptable to external demands. These two types of experts have been characterized as being “merely skilled” versus “highly competent” or “adaptive.”

In Miller’s (1978) study of information system designers, the “merely skilled” experts sought to identify the functions that their clients wanted to automate; they tended to accept the problem and its limits as stated by the clients. This group of designers approached new problems as opportunities to use their existing expertise to do familiar tasks more efficiently. In contrast, the “highly competent” experts treated the client’s statement of the problem with respect, but consider it “a point for departure and exploration.” Similarly, in the culinary arts, there are two types of sushi chefs: one that excels at following recipes, and one that has “adaptive expertise” and is able to prepare sushi quite creatively (Hatano & Inagaki, 1986).

The distinction made about adaptive expertise is akin to what Bereiter and Scardamalia (1993) call “creative expertise,” which embraces a more critical view of expertise in that they downgrade aforementioned “skilled experts” to “experienced nonexperts.” What distinguishes creative experts from experienced non-experts, according to them, rests with the extent to which they are doing progressive problem-solving. As they articulate,

The difference between experts and experienced nonexperts is not that one does things well and the other does things badly. Rather, the expert addresses problems whereas the experienced nonexpert carries out practiced routines...

The career of the expert is one of progressively advancing on the problems constituting a field of work, whereas the career of the nonexpert is one of gradually constricting the field of work so that it more closely conforms to the routines the nonexpert is prepared to execute. (p. 11)

This distinction between creative experts and experienced nonexperts in problem-solving abilities also leads to a difference in risk-taking behaviour. Specifically, creative
experts are more willing to take risks, because “progressive problem solving always involves some risk, some venture beyond what one always knows how to handle” (p. 125). More importantly, Bereiter and Scardamalia (1993) asserted that it was only through the experience of taking bigger and more frequent risks, that they could develop more *knowledge of promisingness*, which in turn further increases their likelihood of success in the future. The knowledge of promisingness stems from progressive problem solving by creative experts and thus, distinguishes creative experts from novices as well as experienced nonexperts.

**Summary**

The review of expertise literature in this section has focused on three aspects of expertise: pattern recognition, tacit knowledge, and adaptive and creative expertise. As articulated at the beginning, these aspects are not mutually exclusive, but rather mutually dependent and deeply interconnected. More importantly, for the sake of this dissertation, a review of these aspects of expertise helps to situate promisingness in the area of expertise. As briefly discussed above, the judgment of promisingness is based on pattern recognition, which is enabled by experts’ rich experience in a domain area. The processes of judging promisingness draws on intuitions, feeling, and non-analytical processes, which largely fall into the tacit dimension of expert knowledge. The purpose of promisingness judgments is to go beyond current best practice, which is a central concern of adaptive and creative expertise. By introducing the roots of promisingness judgments and knowledge of promisingness in expertise research, this dissertation attempts to further expand the current understanding of promisingness and to devise technological supports that foster it within the educational context of knowledge building.
2.2.2 Constructivism

This dissertation research is also rooted in a long standing tradition of learning sciences research, which is based primarily on constructivist learning theories (Sawyer, 2006). The term constructivism is used in a broad range of disciplines, including philosophy, psychology, sociology, and education, and has become increasingly important through the twentieth century and to the present day. From a philosophical point of view, constructivism is an epistemology that aims to explain how people construct knowledge from new information and previous experiences. As Reich (2009) notes,

Unlike metaphysical or realist approaches, constructivists do not look for copies or mirroring of an outer reality in the human mind. Rather, they see humans as observers, participants, and agents who actively generate and transform the patterns through which they construct the realities that fit them. (p. 40)

A tale entitled Fish is Fish (Lionni, 1974) has been widely used to illustrate the central idea of constructivism. It describes a fish that is keen to learn about what happens on land but is unable to do so because it can only live underwater. Luckily it has a friend, a tadpole, who eventually grows into a frog and brings back what it sees on the land. However, everything described by the frog—birds, cows, and people—is conceived by the fish to have some fish-like feature. Cows are fish with udders, birds are fish with wings, and people are fish walking on their tail fins. This tale vividly illustrates the significance of construction and the importance of the background and culture one brings to understanding new information. In essence, constructivism assumes that “knowledge is a function of how the individual creates meaning from his or her experiences,” rather than “a function of what someone else says is true” (Jonassen, Davidson, Collins, Campbell, & Haag, 1995, p. 11).

In education, cognitive and social constructivism represent two strands embraced by educational theorists and practitioners. At the center of the cognitive constructivist camp is the work of Swiss psychologist Jean Piaget. His psychology in cognitive development
has greatly shaped research into the learning processes of children. The main message from Piaget is his *development stage theory*, which asserts that children progress through four universal and consecutive stages of cognitive growth, including *sensorimotor stage*, *pre-operational stage*, *concrete operational stage*, and *formal operational stage* (Piaget & Inhelder, 1969). Each of these phases represents a major cognitive transformation compared to the preceding stage, and it is impossible to skip one stage and move to the next one (Piaget, 1964). Despite “dcalage” (Scardamalia, 1977), this stage theory has had a major influence on models of teaching and learning. For example, it focuses on developmental dynamics and encourages more play, use of visual aids, and interactions with objects in children’s learning; hands-on activities are also thought to be beneficial for learning complex skills (Driscoll, 2004).

Linked to the cognitive development theory is Piaget’s account of the process of change and understanding. To articulate cognitive processes involved in learning, he borrowed the concept of *schema* from philosopher Immanuel Kant to denote the mental framework that is created as children interact with their physical and social environments (Naested, Potvin, & Waldron, 2003). Cognitive development happens when a schema within a child is created or revised. Piaget believed that this process involves two basic functions, *assimilation* and *accommodation*. Assimilation explains how humans perceive and adopt new information. It involves taking in new information in one’s environment and fitting it into one’s current cognitive schemata. In contrast, accommodation is the process of taking new information and modifying a pre-existing schema or forming an entirely new one to fit in new information. Both functions are crucial for conceptual understanding and cognitive changes to take place. Assimilation relates one’s inner mental schema to the environment, while accommodation enables humans to continuously interpret new concepts, schemas, frameworks, and so forth. These two cognitive processes come together to drive cognitive growth in children as they progress along the developmental stages.
Although Piaget also recognized the importance of social interactions for knowledge development, it was Lev Vygotsky's social constructivism that went farther to recognize society as the "bearer of the cultural heritage without which the development of mind is impossible" (Cole & Wertsch, 1996; Driscoll, 2004). In contrast to Piaget's emphasis on stage-wise cognitive development, social constructivists put more emphasis on the social, cultural, and historical factors that influence learning (Vygotsky, 1978). Vygotsky's learning theory bears a much stronger sociocultural orientation than Piaget's, even though these two also share many common perspectives about teaching and learning. Vygotsky argues that all cognitive functions originate in, and must therefore be explained as products of social interactions. Therefore, learning is not simply the assimilation and accommodation of new knowledge by learners, it is the process by which learners are integrated into a knowledge community. Thus, learning should be conceived as a process of assimilation into an established community of practice (Duffy & Cunningham, 1996).

In Vygotsky's (1978) words,

"Every function in the child's cultural development appears twice: first, on the social level and, later on, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher functions originate as actual relationships between individuals. (p. 57)"

This focus on social development lead to his theory of the Zone of Proximal Development (ZPD). According to Vygotsky, the ZPD refers to "the distance between the actual development level of a child 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). The ZPD represents specific circumstances wherein a learner by interacting with a more knowledgeable person can accomplish a task that he/she would otherwise have not been able to accomplish alone. The perspective of ZPD is in line with the notion of instructional scaffolding raised by Jerome Bruner (1976) and has informed designs of learning scaffolds to support
development of learners in a wide range of areas.

Both cognitive constructivism and social constructivism have significant implications for theories of instruction. Overall, the constructivist view of learning dismisses the earlier “transmissionist approach” that assumes knowledge is transferred directly to students, and encourages discovery, hands-on, experiential, collaborative, project-based, and problem-based learning. According to constructivist learning theories, students come to school not as “empty vessels” ready to be filled with knowledge, but with alternative conceptions of the real world (Cobb, 1994). All knowledge is constructed from previous knowledge. And this notion is evident in learning of various subject domains (e.g. Scardamalia, Bereiter, Hewitt, & Webb, 1996; Smith III, DiSessa, & Roschelle, 1994; Vosniadou & Brewer, 1992). In science learning for example, conceptual change instruction recognizes pre-existing knowledge of students as an important aspect of learning (Vosniadou, 2008). Starting with the general understanding that knowledge is constructed, learning theorists have developed a family of constructivist approaches to promote learning. These approaches include, but are not limited to, discovery learning (Bruner, 1961), inquiry-based learning (Schwab, 1960), cognitive apprenticeship (J. S. Brown, Collins, & Newman, 1989), situated learning (Lave & Wenger, 1991), and problem-based learning (Neville, 2009). Perspectives of constructivism have also inspired the design of learning environments and instructional materials (Duffy & Jonassen, 1992). According to Jonassen (1994), constructivist learning environments should (1) provide multiple representations of reality, (2) represent the complexity of the real world, (3) emphasize knowledge construction instead of knowledge reproduction, (4) emphasize authentic tasks in a meaningful context rather than abstract instruction out of context, (5) support learning in real-world settings or case-based learning, (6) encourage thoughtful reflection on experience, (7) enable context- and content-dependent knowledge construction, and (8) support collaborative construction of knowledge through social negotiation, not competition among learners for recognition.
For social constructivism in particular, Vygotsky’s social constructivist theory has inspired theorists to extend the traditional focus on individual learning to address collaborative and social dimensions of learning in recent decades. His theory of social learning has been expanded upon by a number of later learning theorists and researchers. The idea of having a more knowledgeable person to support learners was further extended to having students support each other. This idea stimulates further explorations of social constructivism, informed by different perspectives and theoretical stances grounded on empirical studies. For instance, Brown’s (1997) Fostering Communities of Learners (FCL) program attempted to design an environment in urban classrooms to promote deep learning by turning a class into a community of learners that shows agency, reflection, collaboration, and culture. As another example, Lave and Wenger (1991; 1998) coined the concept of Communities of Practice (CoP) to describe learning through practice and participation in a community. CoP is more concerned with how learning occurs outside the classroom and later evolved from a theory of learning to be a part of the field of knowledge management. More relevant to this dissertation, the Knowledge Building approach also embraces such a sociocultural approach of learning, but emphasizes knowledge creation by students in the community, with collective responsibility for idea improvement (Scardamalia & Bereiter, 2003, 2006).

The present research on promisingness judgments is contextualized in knowledge building, and is therefore rooted in social constructivism. From a Knowledge Building perspective the question is “who controls the zone of proximal development”? (Scardamalia & Bereiter, 1991, p. 48). The typical Vygotskian perspective is to reserve the power of defining ZPD for teachers, instructional designers, and more knowledgeable others. Knowledge Building contends that children can assume control of ZPD—as all knowledge creators must. This requires awareness of goals and principles rather than being blindly engaged in tasks and activities. By engaging students in making promisingness judgments of their communal ideas, students are deciding for themselves which
directions they ought to follow. Moreover, the activity of evaluating community ideas itself is an important sociocultural practice in a knowledge society. This practice is related to multiple aspects concerned with many social constructivist theories, such as reflective thinking and metacognition (Dewey, 1933; Flavell, 1979; P. M. King, 2000). Demonstrating that young students can make meaningful promisingness judgments—a demanding socio-cognitive activity—would certainly “offset the relatively pessimistic view of the child as an (incompetent) learner” (A. L. Brown, 1997, p. 400) and to expand current perspectives of social constructivism.

In the following section, I discuss the knowledge building approach in greater detail, to further situate this dissertation research in an established line of knowledge building research and to highlight key areas this research is aiming to advance.

2.3 Knowledge Building

Stemming from research on expertise and informed by perspectives from social constructivism, knowledge building represents a distinctive approach towards foster expert-like learning through engaging learners in a knowledge creating context. Discussion of its distinctiveness can be found in a broad body of literature on Knowledge Building. Below, I highlight important aspects pertinent to the study of promisingness judgments.

2.3.1 Deep Constructivism and Collective Cognitive Responsibility

The general public and researchers tend to confuse Knowledge Building with its “near-neighbor” constructivist approaches, such as guided discovery and inquiry learning. Even though efforts to distinguish between different approaches are evident in the literature (e.g., Scardamalia & Bereiter, 2007), the boundaries among these different approaches are not clear cut.
Knowledge Building can be distinguished from other approaches by a combination of the following characteristics:

First, Knowledge Building requires *deep constructivism*. As Scardamalia and Bereiter (2003) convey, constructivist approaches can be viewed along a continuum from shallow and deep constructivism, depending on the extent to which students assume responsibility in their learning. Knowledge Building requires that students take over the highest level cognitive dimensions typically assumed by the teacher (e.g., planning, monitoring, assessing), in addition to more tangible and practical aspects of knowledge processes (Scardamalia, 2002).

Shallower forms of constructivism engage students in tasks and activities, with responsibility for various aspects of the work (e.g., generating questions, conducting experiments, etc.), but typically goals and the “big ideas” that give meaning to their work are set by the teacher (usually following curriculum guidelines) and have no overt presence. Accordingly students tend to describe the activities they are engaged in with little awareness of the underlying principles that these tasks are to convey. In the deepest forms of constructivism, participants set the goals and redefine them as new challenges emerge. That is what allows them to advance the frontiers of knowledge in their community. Identifying problems of understanding, establishing and refining goals based on progress, gathering information, theorizing, designing experiments, answering questions and improving theories, building models, monitoring and evaluating progress, and reporting are all directed by the participants themselves toward knowledge building goals.

This distinction around cognitive responsibility also has important implications for the roles of teachers. Bereiter and Scardamalia (1987) distinguishes three idealized models of teachers, which are further elaborated by them in multiple occasions (Scardamalia, 2002; Scardamalia & Bereiter, 1991). In a classroom led by *Teacher A*, which is typical in many school settings, the focus of schoolwork centers on finishing tasks, with teachers guiding students through materials, asking questions, diagnosing students’ understanding, and
making remedies accordingly. Even though students may be hard-working, they have minimal understanding of the learning process. The teacher may execute teaching with minimal amount of preparation, such as following the textbook and teaching manuals. Teacher B, in contrast, would focus more on understanding rather than tasks. The teacher’s role would include setting cognitive goals, activating prior knowledge, asking thought-provoking questions, monitoring progress, and providing directions. She may further design and carry out activities to scaffold or contextualize students’ learning, or to make their learning fun and enjoyable. Teacher B could, in some cases, be celebrated as a model teacher because of the care she puts into planning her classes. However, ultimately cognitive responsibility resides with Teacher B, while her students are not expected to have awareness of objectives behind learning tasks or activities. In contrast, the Teacher C model is the model of a Knowledge Building teacher. Teacher C attempts to turn agency to students—to make them responsible for their own learning. Students are expected to gradually take the responsibility of setting their own goals, coming up with strategies, diagnosing progress, and continuously refining their goals, which is essentially what Teacher B does for her students. Although this proximal setting is not accomplished all at once, turning more agency and cognitive responsibility of learning to students is the main goal for Teacher C.

Building on the notion of cognitive responsibility, the second distinction of knowledge building is that such responsibility should be taken collectively among students. Ideally, a knowledge-building classroom functions like expert teams in the workplace. In expert medical teams, flight crews, and sports teams, while each member may have a particular area of expertise and a distinctive way of contributing to the team, all team members are also able to take over for one another on a moment-to-moment basis (Scardamalia, 2002). So for students assuming collective cognitive responsibility, their goal is to bring their individual talents to the group enterprise, to help the group succeed as a whole. Thus, Knowledge Building emphasizes attention to group success, and students have a
mindset to contribute their best to building knowledge as a community.

Last but not least, the goal of Knowledge Building is to create knowledge—to engage students in the ways of expert teams and knowledge-creating organizations. Through engagement in these complex social interactions focused on the creation of public artifacts that have an existence beyond their personal understanding, students are not only positioned to learn in the process but to create new knowledge. As articulated by Scardamalia and Bereiter (2003, p. 3): “Learning is an internal, unobservable process that results in changes of belief, attitude, or skill. Knowledge building, by contrast, 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.” Whether it is scientists working in real-world laboratories (Dunbar, 1995), company employees trying to come up with the next innovation (Nonaka, 1994), or elementary students trying to advance their understanding (Zhang, Scardamalia, Lamon, Messina, & Reeve, 2007), they share a similar goal of advancing the frontiers of their collective knowledge. Although the perceived knowledge frontier in different contexts varies—in line with differences in the knowledge domains and the level of expertise—the goal and process are essentially the same, with learning an important “by-product.”

The role of promisingness judgments—the main concern of this dissertation—is an important and challenging aspect of collective cognitive responsibility. Evaluating promisingness of ideas will help a community identify and advance their knowledge frontiers, with needed direction and redirection as work proceeds. Because knowledge creation is complex and cannot be easily achieved, identifying the most promising ideas to labor on becomes especially important. So, when we ask the question “who controls the zone of proximal development” (Scardamalia & Bereiter, 1991), we are essentially asking who defines a knowledge-building community’s knowledge frontiers and future directions. Thus, the practice of making promisingness judgments sits at the heart of collective cognitive responsibility in knowledge building and represents students’ critical action of having
students steering their own knowledge building processes.

### 2.3.2 Design Thinking in Theory Building

Since Knowledge Building concerns idea improvement and knowledge production, an important question is how to set students onto a trajectory of improving their understanding. According to Bereiter (2012a), a powerful way to advance understanding is through developing explanatory theories and improving them on the basis of evidence and reasoning. This notion reflects many cases in the history of science. For instance, Darwin’s work on the idea of “natural selection” is described as a process of discarding or modifying his ideas ruthlessly based on obtained evidence and insights in different contexts. His mode of thought, supported by his capacity for throwing away some ideas and maintaining a variety of ideas ready to be incorporated together, enabled him to weld everything he had into a biological law (Gruber, 1981). Based on analysis of changes of the central concepts surrounding the nature of human existence (e.g., life, mind, and disease) in the past 150 years or so, Thagard (2008) identifies a progression from theological, to qualitative, to mechanistic explanations of these phenomena—a progression involving theoretical change, as new theories with greater explanatory power replace older ones. Such progression, as seen in individuals like Darwin or in the history of science, can be summarized by Thomas Kuhn’s (1977) discussion of *theory choice*: people work to establish good scientific theories, which are more accurate and consistent; with a broader scope; closely related to other established theories; and fruitful. The key messages from all these studies is that to build powerful theories, ideas ought to be put onto a trajectory of growth, ready to be modified, merged, linked, or discarded.

As applied in education at the school level, Knowledge Building embraces a broad definition of theory, including explanatory statements uttered by students (Bereiter, 2012a). With this more relaxed and simplified definition, young students are found capable of proposing their own theories to explain all sorts of phenomena around them. For exam-
ple, as reported in previous knowledge building research, Grade 1 students explain “why leaves change color” with the theory that “it’s too cold for the chlorophyll to make food for the tree” (Scardamalia, 2002, p. 13); Grade 3 students explain “how worms sense light without eyes” by speculating that “they can sense temperature to tell whether it’s light or dark” (B. Chen, Scardamalia, Resendes, Chuy, & Bereiter, 2012); Grade 4 students explain “why Shakespeare was in Medieval Times?” by analyzing and comparing his clothes with people from different eras (Resendes & Chuy, 2010). As shown in these examples, students are able to propose quite complex theories. This natural capability of young students to conjecture, explain, and theorize is at the heart of knowledge building.

After a theory is proposed, a great deal of work must continue on the “building” part. In the history of science, a theory should stand up against evidence tests and criticism. If not, a theory will be falsified, or at least overshadowed by more advanced ones. That was the case for the long-standing battles of the heliocentric versus geocentric theories of the solar system, or of Darwin versus Lamark over evolution. Thus, after someone puts forward a theory, substantial work is needed to further “build” it, putting it onto a trajectory of change and improvement (Scardamalia & Bereiter, 2006). The building part is key in knowledge building. As Bereiter (2012a) points out, many approaches remain content with having students producing, or in a more commonly used term, “brainstorming” explanatory ideas while making no attempt to further test or develop them. What knowledge building focuses on, in the process of theory building, is to continually increase the “explanatory power” of theories. Such explanatory power could be judged in light of a list of criteria, as those articulated by Kuhn (1977) and Bereiter (2012a), which are concerned with the superiority of one theory against another. A higher level of explanatory power may also signal improved explanatory coherence (Thagard, 1989), which concerns relationships between propositions associated with different theories. It is important to note that the process of building theories for stronger explanatory power differs from a didactic approach to teaching wherein a theory is considered better only if
it approaches an authoritative theory.

The emphasis on the building part in knowledge building is further synthesized as design-mode thinking (Bereiter & Scardamalia, 2003; Scardamalia & Bereiter, 2007). As observed by Scardamalia and Bereiter (2007), most creative knowledge work is carried on in design mode. “In design mode, the concern is not with ideas as objects of belief but with ideas as objects of creation, development, assembly into larger wholes, and application ” (p. 14). The idea of design-mode thinking echoes a similar spirit of promoting a “designerly way of knowing” in general education, stemming from design professionals (Cross, 1982). The design-mode approach is contrasted with a belief-mode approach, which is concerned with “what we and other people believe or ought to believe” and arriving at true or warranted beliefs (Bereiter & Scardamalia, 2003, p. 3). In knowledge building processes, both modes are essential; the key is flexible movement between. The challenge comes from the fact that education is conducted almost exclusively in belief mode so students do not have the chance to venture into design mode. They end up debating which of given alternatives is better rather than contemplating something beyond given alternatives. Thus, when envisioning future education, Bereiter and Scardamalia (2008) advocate for engaging students to work more in design mode in order to drive research-based innovations.

The distinction between design-mode thinking and belief-mode thinking is reflected in the difference between truthfulness and promisingness. In belief-mode thinking, the central task is to arrive at “true” ideas, so truthfulness provides the central criterion for evaluating ideas. In contrast, in design-mode thinking, a more important concern is to put ideas onto a promising trajectory of growth. In this case, what matters is not an idea’s truthfulness at present, but its promisingness in light of future endeavors, should the community choose to labor on it. Thus, evaluating promisingness of ideas is a central component of design-mode thinking and ought to be supported in knowledge building.
2.3.3 Epistemological Framework of Knowledge Building

Underpinning collective cognitive responsibility and design-mode thinking is Karl Popper’s “Three World” epistemology. He challenges monist and dualist views of the universe, and proposes a view that recognizes three different but interacting sub-universes (Popper, 1972, 1978). Three worlds in his cosmology are: World 1—“the physical world,” including non-living physical objects and biological objects; World 2—“the mental or psychological world, the world of our feelings of pain and of pleasure, of our thoughts, of our decisions, of our perceptions and our observations; in other words, the world of mental or psychological states or processes, or of subjective experiences” (Popper, 1978, p. 143); and World 3—the body of human knowledge expressed in its manifold forms, or the products of the second world made manifest in the materials of the first world (i.e., books, paintings, music, sculptures, airplanes, and all the products of the human mind).

The three different worlds can interact with each other. For example, Shakespeare’s *Hamlet* (World 3) can be embodied in a printed book (World 1), and can also live in many people’s minds (World 2). His central argument is that objects in World 3 have an existence and evolution independent of any individual knowing subjects. In his own words (Popper, 1978),

> Are world 3 objects, such as Newton’s or Einstein’s theories of gravitation, real objects? Or are they mere fictions, as both the materialist monist and the dualist assert? Are these theories themselves unreal, and only their embodiments real, as the materialist monist would say; including, of course, their embodiments in our brains, and in our verbal behavior? Or are, as the dualist would say, not only these embodiments real, but also our thought experiences; our thoughts, directed towards these fictitious world 3 objects, but not these world 3 objects themselves?

> My answer to this problem... is that world 3 objects are real; real in a sense very much like the sense in which the physicalist would call physical forces, and fields of forces, real, or really existing. (p. 152)

He distinguishes sharply between *knowledge in the subjective sense* and *knowledge in the objective sense*: knowledge in the subjective sense consists of specific mental dispositions and thought processes in World 2, whereas knowledge in the objective sense,
which lives in World 3, consists not of thought processes but of thought contents. This
distinction has important implications, leading him to contend that the growth of human
knowledge is a function of the independent evolution of World 3, and it is only through
the existence of World 3 that any type of knowledge advancement can be made. As
Popper (1978) writes,

It is the objective thought content of a conjecture or theory on which the
scientist’s subjective thought processes work. They are at work to improve
the objective thought contents by way of criticism. It is true that the scientist
has to grasp subjectively the implications of the objective theories, before he
can apply these theories in order to change our physical environment, which
is part of world 1. That is to say, world 2 acts as an intermediary between
world 3 and world 1. But it is the grasp of the world 3 object which gives
world 2 the power to change world 1. (p. 158)

In line with Popperian epistemology, Knowledge Building treats ideas as real things—
as objects of inquiry with their own lives in World 3 (Scardamalia & Bereiter, 2003). This
epistemology is happily married to Knowledge Building’s emphasis on “building,” espe-
cially that the building needs to take place collectively. In Knowledge Building, object-
tifying ideas as cultural artifacts (Bereiter, 2002b) is the starting point of putting them
onto a trajectory of improvement. Community knowledge-building discourse provides
the means to maximize the potential of idea improvement. Just like Popper’s description
of the scientist’s work on theories, students pick up ideas in their community, World 3
space, modify them, and add on to the community space. The sense of ideas belonging
to a community, or living in World 3, is crucial for helping students to go beyond winning
arguments and engage in idea improvement as a collective.

Popperian epistemology also guides the development of knowledge-building environ-
ments. CSILE/Knowledge Forum, the most widely used knowledge-building environ-
ment, was designed to provide a range of technological supports to enable students to
operate as knowledge workers in an open space (Scardamalia, 2004; Scardamalia, Bere-
iter, & Lamon, 1994); improving ideas, including actions of representing and organizing
ideas; linking ideas together and collaborating with others; assessing ideas, monitoring
progress, and moving ideas to higher levels (Scardamalia, 2003). Work on expertise, innovation, and self-organization, along with Popperian epistemology, provides principle-based guidance for the design of such functions, all serving the purpose of putting ideas center-front to support their growth in new and varied forms.

2.3.4 Knowledge Building Pedagogy

Knowledge building pedagogy takes a principle-based rather than procedure-based approach to instruction (Scardamalia & Bereiter, 2006). It is defined with a goal to turn high-level agency to students and organized around twelve principles, which together “set a knowledge building classroom off as profoundly different from even the best of traditional and modern classrooms” (Scardamalia, 2002):

Real Ideas and Authentic Problems. Students identify problems that arise from their efforts to understand the world and pursue sustained creative work surrounding them.

Improvable Ideas. Ideas are treated as improvable rather than simply accepted or rejected; students work continuously to improve the explanatory power, coherence, and utility of ideas.

Epistemic Agency. Students set goals, assess their work, engage in long-range planning, monitor idea coherence, use contrasting ideas to spark and sustain knowledge advancement, and engage in high-level knowledge work normally left to the teacher.

Collective Responsibility for Community Knowledge. All participants are legitimate contributors to community goals and take high-level responsibility for advancing the community’s knowledge, not just for their individual learning.

Democratizing Knowledge. All participants are empowered as legitimate contributors to the shared goals; all take pride in knowledge advances of the community. Diversity and divisional differences are viewed as strengths rather than as leading to separation along knowledge have/have-not lines.

Idea Diversity. Knowledge advancement depends on the diversity of ideas, just as the success of an ecosystem depends on biodiversity. To understand an idea is to understand the ideas that surround it, including those that stand in contrast to it.

Knowledge Building Discourse. Students engage in discursive practices that not only share but transform and advance knowledge, with problems progressively identified and addressed and new conceptualizations built.
Rise Above. Students work with diverse ideas in complex problem spaces; they transcend trivialities and oversimplifications and work toward more inclusive principles and higher level formulations of problems.

Constructive Use of Authoritative Sources. Participants access and critically evaluate authoritative sources and other information. They use these sources to support and refine their ideas, not just to find “the answer.”

Pervasive Knowledge Building. Knowledge Building is not confined to particular occasions or subjects but pervades mental life—in and out of school and across contexts.

Symmetric Knowledge Advance. Expertise is distributed within and between communities and team members, with knowledge exchange and construction reflecting the understanding that “to give knowledge is to get knowledge.”

Embedded and Transformative Assessment. Assessment is integral to Knowledge Building and helps to advance knowledge through identifying advances, problems, and gaps as work proceeds. (pp. 9-12)

These principles guide knowledge practices in knowledge building classrooms, but do not impose a particular instructional procedure. This principle-based approach is essentially different from many contemporary forms of instruction, represented by popular models such as project-based learning (Marx, Blumenfeld, Krajcik, & Soloway, 1997), often defined by activities and tasks, to meet pre-specified learning goals. By departing from emphasis on projects and shifting the focus to applying principles, Knowledge Building depends on teacher inventiveness and student agency and discoveries to keep knowledge practices centered on ideas instead of tasks and activities. Knowledge building principles serve as guideposts to engage a classroom in idea development to support community knowledge advancement (not simply individual achievement; results suggest contributions to community work lead to individual achievement), to promote continual idea improvement (not simply attainment of “true and warranted” belief; knowledge builders are no less attuned to these beliefs, as knowledge building engages them directly with goals and authoritative sources surrounding their work), to focus on knowledge of a domain (in addition to knowledge about a domain), by means of discourse aimed at explanation and idea improvement (not simply argumentation) and constructive (not simply assimilative) use of authoritative sources (Scardamalia & Bereiter, 2006).
The principle-based nature of knowledge building pedagogy can be frustrating for practitioners looking for procedural guidelines. As the creators of this pedagogy admit, “working from principles, especially in the absence of specific activity structures, has proved exceedingly difficult for knowledge building pedagogy,” and there is considerable disagreement among promoters of knowledge building about the best strategy for getting teachers started (Scardamalia & Bereiter, 2007, p. 26). For example, while some colleagues suggest starting from principles (Tarchi et al., 2011), other colleagues propose phase-based instructional design for knowledge building (E. Y. C. Lee, Chan, & van Aalst, 2006). In Lee and colleagues’ semi-procedural approach, the process of knowledge building is broken down into four phases: (a) developing a collaborative culture: students were asked to put ideas into the public; (b) knowledge-building inquiry: Knowledge Forum was introduced and students engaged in posing problems, making conjectures and hypotheses, co-constructing explanations, and comparing different theories and explanations; (c) deepening and rise-above: students deepened their understanding using rise-above notes and synthesized their understanding; and (d) alignment of assessment: students wrote reflections and created e-portfolios identifying their own progress, as well as community progress in knowledge building. Given that test scores and efficiency are always a concern for high-stake educational contexts (Sahlberg, 2011), especially in East-Asian countries (e.g., Gregory & Clarke, 2003), this approach could mitigate anxiety of teachers and appear more manageable to teachers, especially teachers who are new to knowledge building.

However, adopting such an intermediate step should not stop teachers from going forward to fully embrace the principle-based approach. Teaching in knowledge-building classrooms should be treated as a “design science” itself (Laurillard, 2012). When teachers get started with such an intermediate model, it is important to help them see knowledge building as a system, where the principles are conducive to one another, or in Scardamalia’s words, “implementing one tends to unlock the others” (Scardamalia, 2002,
Thus, while it may be a challenge to achieve all knowledge-building principles at once, a practical solution may be to start from a few principles and gradually adopt others, as long as the long term plan does not get downgraded to achieving efficiency of procedures.

Regardless of the potential barriers at the initial stages of adopting knowledge building, the fruitfulness of the pedagogy itself is widely documented in the literature spanning across different age levels. For example, Zhang, Scardamalia, Reeve, and Messina (2009) described social configurations in a Grade 4 knowledge building classroom, where the teacher’s goal was to support his students in assuming increasing levels of collective responsibility for advancing their knowledge of optics. In a three-year effort involving the whole class collectively focused on improving their practice (same teacher, different students each year), by the third year, the class developed an interaction model similar to that of organic and distributed social structures in real-world knowledge-creating organizations, leading to the highest level of collective cognitive responsibility, knowledge advancement, and dynamic diffusion of information. It also led to highest achievement scores. More examples can be found in Scardamalia, Bereiter, Hewitt, and Webb (1996) and Messina and Reeve (2006). Under optimal condition, knowledge building operates as a school-wide principle-based innovation, with students, teachers and the principal participating (Zhang, Hong, Scardamalia, Teo, & Morley, 2011).

### 2.3.5 Knowledge Building Environments, Knowledge Forum

While knowledge building does not require a technical environment, a knowledge building environment has the potential to greatly facilitate the process. Knowledge building environments help get ideas out into the world and onto a path of continual improvement, sustain knowledge-building discourse, and provide reference points for both online and face-to-face discussions. They also support the self-organization of students around ideas and their growth in a community space, lowering the need for external guidance, facili-
tating self-adjusting systems for division of labor, and allowing for knowledge emergence in a community.

CSILE/Knowledge Forum is the predominant knowledge-building environment designed specifically to support the above processes. It is designed with provisions and scaffolding supports for idea improvement, graphical means for viewing and reconstructing ideas from multiple perspectives, mechanisms for joining discourses across communities, and a variety of other functions geared towards collaborative knowledge building (Scardamalia & Bereiter, 2003). On the surface, the main constituents of Knowledge Forum are notes and views. A note is the basic unit in Knowledge Forum (see Figure 2.1). In the form of notes, participants contribute theories, explanations, designs, plans, evidence, authoritative sources, and so forth to this communal space. Notes can be linked in different ways, in knowledge building terms of building on and referencing. A view is a two-dimensional organizing background for notes (see Figure 2.2). In a view, users have the freedom to organize notes in whatever manner is most favorable to knowledge building. Users can place notes in specific spots. They can also add graphic structures, such as a concept map, a diagram, or a scene, to help organize notes in meaningful ways. With views and notes, Knowledge Forum provides an open, communal space for a community to engage in idea development. Although notes can be aligned in the familiar conceptual hierarchical structure of threads and posts in threaded discussion, the emphasis is on creating conceptual frameworks through use of self-constructed graphical backgrounds to provide context for and emphasis on idea improvement.

Based on the basic structure of notes and views, Knowledge Forum provides rich affordances to support knowledge building processes. While notes and views achieve the central goal of objectifying ideas, Knowledge Forum is also designed with more sophisticated support for the socio-cognitive practices of knowledge-building discourse. Key affordances of Knowledge Forum described by Scardamalia (2004) include:

- **Multiple Perspectives, Multiple Literacies, and Teamwork.** The communal space
Figure 2.1: A Knowledge Forum note, in which ideas are contributed. In a note, users can specify the problem they want to address, use scaffolds (e.g., My theory) to frame ideas, and add keywords to convey the essence of the note.

Figure 2.2: A Knowledge Forum view, a problem space created and designed by a knowledge-building community to conceptually organize ideas contributed in the form of notes.
constructed by notes and views, which can be individually or group authored, support teamwork and collaboration. Multimedia support in notes and views enables different ways of working with ideas. Freedom of organization in a view enables different perspectives on the same information, and promote emergence of ideas and goals in the knowledge space.

- Creating Connections and Public Knowledge. Knowledge Forum encourages interconnections among ideas. Build-on links embody the motive to improve ideas. Reference links encourage work from existing ideas; they also include pointers back to source notes, so that ideas can be viewed in both original and new contexts. Notes can also be linked through multi-faceted semantic markers, including keywords, problems, and scaffolds, and other automatically assigned metadata (such as author, date). Last but not the least, views can also be flexibly interlinked, to indicate connections between them.

- Advanced Knowledge Processes. Each note has a problem field for explicit statement of the problem of understanding it tackles. It encourages the identification of problems of understanding to guide inquiry. Scaffolds, e.g., “My theory”, “I need to understand”, give ideas defined roles in knowledge processes and encourage different ways of contributing to knowledge-building discourse. By customizing scaffolds, advanced knowledge processes, such as theory refinement and constructive criticism, can be supported. Reference and citation in Knowledge Forum imitate scholarly publication practice. They guide students to understand the public knowledge space before writing and encourage a sense of contributing to the community rather than writing for themselves or the teacher.

- Rise-Above and Improvable Ideas. In knowledge building, all ideas are improvable. Knowledge Forum supports review and revisions of notes. Idea improvement sometimes requires users to “rise-above” current ideas to deal with higher level coherence. Knowledge Forum provides a “rise-above” function that collapses a set
of notes into a rise-above note and invites users to describe a higher-level idea that they can further work on.

- **Ideas and Artifacts as Objects of Discourse.** Knowledge Forum envisions incorporating as an object of discourse anything that can be represented digitally. It currently supports text, pictures, drawings, hyperlinks and videos, and expects to support more formats in the future.

- **Embedded and transformative assessment.** Knowledge Forum automatically records activities such as reading, building-on, referencing, and creating views. Analytic tools specially designed for various purposes harness relevant data, compile meaningful results, and feed back into the work as it proceeds, in order to inform and transform ongoing knowledge-building discourse. Such analytic tools monitor various aspects of Knowledge Forum activities including contributions, social networks, vocabulary use, and so forth.

In summary, Knowledge Forum is a multimedia communal knowledge space that supports continual idea improvement of a knowledge building community. It embodies Popperian epistemology, knowledge building theory, and knowledge building principles. It is neither a tool nor a collection of tools; rather, it is an environment that supports creative work with ideas in knowledge-building organizations of all kinds (Scardamalia, 2004). As Scardamalia and Bereiter (2006) describe,

> Knowledge Forum is where the main work takes place. It is where the “state of knowledge” materializes, takes shape, and advances. It is where the results of the various off-line activities contribute to the overall effort. (p. 108)

Knowledge Forum has been continuously improved over the years based on research results rising from its broad international user communities. Its ongoing development reflects new advances in knowledge building theory, principles, pedagogy, and classroom practices.
2.3.6 Application of Knowledge Building in Science Education

Knowledge building pedagogy is widely applied from primary to tertiary education in different subject areas such as science, history, languages, and medicine. In the elementary school setting, as I have observed, knowledge building has been most actively applied in the area of science, and there are a couple of reasons for this. One of the most obvious reasons is that explanation building has been widely recognized as an important enterprise in science learning. Compared to other subject areas, such as mathematics and history, science education has a longer tradition of focusing on explanation building (Carey & Smith, 1993). In contrast, in mathematics, teaching practices often focus on acquisition of rules by practice and drills (Gonzalez Thompson, 1984; Kidwell, Ackerberg-Hastings, & Roberts, 2008); or in history, on memorizing facts rather than explaining historical facts (Downey & Levstick, 1991). Nonetheless, powerful examples of knowledge building pedagogy exist across the curriculum (Scardamalia & Egnatoff, 2010). The present dissertation research was conducted in elementary science classrooms. Thus, it is important to review the application of knowledge building in science education in this dissertation. In this section, I review a few important aspects of applying knowledge building in science education.

Stances of Knowledge Building towards Science Education

The knowledge building approach as applied in science education embodies a novel view of science. Reflecting its emphasis on “design-mode thinking,” knowledge building treats science learning as a matter of improving existing knowledge, rather than a “march towards the Truth” from a positivist viewpoint, or working towards a body of dubious opinions and practice from a postmodernist perspective (Bereiter, Scardamalia, Cassells, & Hewitt, 1997). In line with Thomas Kuhn’s (1996) explanation of scientific revolutions, Paul Thagard’s (1989) analysis of theory change, and Kevin Dunbar’s (1995) studies of scientific reasoning in real-world laboratories, knowledge building views scientific inquiry
and science learning as an endeavor to build explanations that have “explanatory power” in describing natural phenomena or accepted facts.

In knowledge building, this theory improvement point of view is applied directly to students’ own efforts to learn science (Bereiter, Scardamalia, et al., 1997). To make sense of a puzzling phenomenon, children can usually propose a hypothesis, no matter how naive it could be, and start from there to build more powerful explanations. In essence, this effort is not different from the scientific investigations by scientists, regardless of the difference in content knowledge and cognitive capacities between the two groups. This view is based on a strong argument that students are legitimate contributors to knowledge creation in the society and they can actually create knowledge (Scardamalia & Bereiter, 2010).

For knowledge building or knowledge creation, progressive discourse is the means to improve scientific theory. It is the case for real-world scientific inquiry, and it is the same for elementary science classrooms doing knowledge building. In “real-world science,” the medium for discourse is usually journals, conferences, seminars, and more recently, social media. In science classrooms, such progressive discourse could take place in both face-to-face and online discussions, where students can share their intuitive ideas and move towards crafting increasingly deep levels of explanations (Hakkarainen, 2003b). What is shared by scientific discourse in these different settings is the commitment to progress. Bereiter (1994) further elaborates this commitment to include four different aspects, including:

A commitment to work toward common understanding satisfactory to all.
A commitment to frame questions and propositions in ways that allow evidence to be brought to bear on them.
A commitment to expand the body of collectively valid propositions.
A commitment to allow any belief to be subjected to criticism if it will advance the discourse. (p. 7)

These four aspects of commitment define the type of progressive discourse leading to scientific progress in knowledge building classrooms. They also distinguish such discourse
from other type of discourse, for example argumentation-oriented discourse promoted in many science classrooms (D. Kuhn, 1993).

**Knowledge-Building Discourse in Science Learning**

The notion of “talking science”—doing science through the medium of language (Lemke, 1990)—has garnered increasing attention in science education. Collaborative conversation has been found to contribute to conceptual change in science learning (Miyake, 2008; Roschelle, 1992). Moreover, discourse is generally emphasized in social constructivist approaches for science learning because peer interactions and knowledge sharing are thought to be meaningful and valuable (Richmond & Striley, 1996; Stahl, 2006).

Knowledge building holds an even stronger belief in the role of discourse in learning: “the state of public knowledge in a community only exists in the discourse of that community, and the progress of knowledge just is the progress of knowledge-building discourse” (Scardamalia & Bereiter, 2006, p. 12). As Bereiter, Scardamalia and Hewitt (1997, p. 338) assert, “This kind of discourse must be regarded as more than merely a vehicle for teaching science content and methods. In a real sense, we have argued, knowledge-building discourse is scientific method, and so students who fail to master it have failed to master science.” This belief is manifested in science learning and documented in knowledge building literature (e.g., Scardamalia, 2002; Scardamalia, Bereiter, & Lamon, 1994).

Knowledge-building discourse focused on conceptual understanding and collaboration can serve as a paradigm for a different approach toward science teaching and science learning, one better suited to the world students are growing into, in which they must be able to work with knowledge—creating it, evaluating it, organizing it, finding new uses for it, and so on (Drucker, 1994).
Knowledge Building as a Facilitator of Conceptual Change

Knowledge building when applied in science education strives to help students achieve conceptual change in learning scientific concepts. Conceptual change literature discusses the ways in which students make progress in science learning. In earlier research, conceptual change was studied from the cognitive perspective involving cognitive conflict (Posner, Strike, Hewson, & Gertzog, 1982), epistemological commitment in knowledge restructuring (Vosniadou & Brewer, 1987), structural change from knowledge in pieces to systematicity (DiSessa, 1988, 1993), and ontological shifts (Chi, Slotta, & De Leeuw, 1994). As learning became more commonly conceived as a sociocultural process (Vygotsky, 1978), conceptual change was increasingly examined from the sociocultural perspective, which highlights the enculturation of practice, discursive interactions, and the social construction of knowledge in the classroom (Saito & Miyake, 2011; P. Scott, Asoko, Leach, Abell, & Lederman, 2007). Knowledge Building, which emphasizes progressive idea improvement through collective discourse, is in line with this sociocultural trend toward the facilitation of conceptual change in science.

According to a rich body of literature, knowledge building is effective in promoting conceptual change. For example, Chan, Burtis and Bereiter (1997) found that knowledge building mediates the effect of conceptual conflict (Posner et al., 1982) in conceptual change instruction. Applying a recognized conceptual-conflict strategy that was thought to foster conceptual change (Posner et al., 1982), the researchers presented students with conceptual-conflict statements and collected their think-aloud data during the process. Analysis of students’ knowledge-processing activities indicated conflict alone was not enough to trigger conceptual change; rather, it was mediated by students’ knowledge-building activities. More specifically, students who responded to conflicts by engaging in knowledge-building activities showed “an active stance in identifying conflict and at-

---

1The conceptual-conflict instructional approach typically involves identifying students’ initial state of understanding and catalyzing confrontation so that students’ initial mis-conceptions could be replaced with scientific ones.
tempt[ed] to reconcile the discrepancies;” they did not avoid conflict, but instead, used the contradictory statements as “opportunities for upgrading their domain understanding” (Chan, Burtis, & Bereiter, 1997, p. 29). In contrast, students who did not employ this approach were inclined to provide a one-shot explanation to eliminate discrepant facts that did not fit their beliefs, and they were less likely to achieve conceptual change. Therefore, in this study, conflicts that did not trigger knowledge-building activities were not effective in producing conceptual change, which suggests that knowledge building mediates the effects of conflicts in conceptual change instruction. This result was also replicated in a later study (Vosniadou & Kollias, 2003).

The effects of knowledge building on conceptual change were also studied in absence of any specific conceptual change instructional strategy. For example, van Aalst (2009) analyzed Knowledge Forum activities of four groups of students who were studying SARS and Avian Flu. Results indicated that the group which presented the strongest features of knowledge building—such as a sense of community, explanation-seeking inquiry, interpreting and evaluating information, knowledge advancement, and insights into these processes—achieved the most conceptual progress. In another study, Lam and Chan (2008) compared a “KB” class with a “non-KB” class and found that the KB class achieved more conceptual change than the non-KB class, where conceptual change was represented by the number of fixed misconceptions and bigger growth in conceptual change tests. Effects of knowledge building on conceptual change can be also found in a number of other studies (Caswell & Bielaczyc, 2002; Hakkarainen, 2004; Zhang, Scardamalia, Lamon, et al., 2007).

Although benefits of knowledge building for conceptual change have been widely documented, it should be noted that systemic design efforts are usually needed to make them happen. Treating knowledge building itself as improvable, Zhang and colleagues (2009) attempted to design knowledge building environments to support students in taking collective cognitive responsibility for sustained idea improvement. This study
depicts a gradual design process to help a Grade 4 class departing from a fixed small-
group structure towards opportunistic collaboration on shared, top-level goals. Results
indicated that as students gradually assumed a higher level of responsibility in their work,
their classroom became an increasingly organic, flexible, and distributed social structure.
Their depth of scientific understanding, measured by epistemic complexity and scientific
sophistication also increased. This study highlighted socio-cognitive processes behind
conceptual change achieved by knowledge building students.

In summary, knowledge building was found a mediator in both conceptual change
instruction and regular discourse-centered learning. This effect could be a synergistic
effect of a variety of benefits of knowledge building, including students’ active stance
of seeing themselves as contributors, their engagement in theory building, and their
attempts to assume epistemic agency. These elements of knowledge building do not
happen naturally in traditional methods of science instruction. Intentional design efforts
are needed to make them happen.

Knowledge Building as a Facilitator of Epistemic Beliefs

Conceptual change in science often involves changes in students’ views about the nature of
science (Duit & Treagust, 2003; Hofer & Pintrich, 1997; Nussbaum, Sinatra, & Poliquin,
2008). Students’ intentions, epistemic beliefs, motivation, and agency all play important
roles in restructuring their knowledge for conceptual change (Sinatra & Pintrich, 2002);
students’ metaconceptual awareness is equally important for conceptual change (Vosni-
adou, 2008). Knowledge building, which embraces a complex framework of epistemology
and principles (see Section 2.3), is well aligned with domains of epistemic development
advocated by conceptual change researchers. Specifically, knowledge building principles
(e.g., collective responsibility, epistemic agency, and idea improvement) are conducive
to growth in areas such as intentional goal-directed strategies, metaconceptual aware-
ness, and epistemic beliefs (Vosniadou, 2008). Thus, applying the knowledge building
approach in science learning has the potential to boost students’ epistemic beliefs.

In previous research, changes in students’ epistemic beliefs advanced in relation to knowledge building in science learning. In Caswell and Bielaczyc’s (2002) study of a Grade 5/6 knowledge building class, they reported a departure from the view of science knowledge as a fixed entity—as “factual, objective, and independent of human distortion”—towards the belief that scientific ideas are tentative and subject to refinement and replication. According to Caswell’s personal reflection as the teacher in that study, this shift is attributed to the knowledge transforming discourse enabled by the knowledge building pedagogy and Knowledge Forum. A comparison study focusing on epistemic beliefs was conducted by Lam and Chan (2008), wherein students in an experimental KB class achieved more epistemic changes than students in a non-KB class. In particular, the researchers found that Knowledge Building students “made more changes from viewing knowledge as simplistic towards complex notions; and from seeing knowledge as static towards knowledge as extendable” (p. 464). Such sophisticated beliefs were consistent with those fostered in a collaborative knowledge-building community. Further analysis suggested that students with more sophisticated beliefs were more likely to engage in deeper reflection and more frequent collaboration activities in Knowledge Forum (notes read, notes linked, and keywords).

Gains in epistemic beliefs were also shown in a study focusing on students’ scientific literacies (Chuy, Scardamalia, et al., 2010). Adopting Carey and Smith’s (1989; 1993) Nature of Science Interview, this study investigated students’ levels of understanding in the nature of science over the span of four months. By doing pre- and post-interviews with two classes of Grade 4 students studying a similar content area—one experimental class adopting the knowledge building approach and the other class adopting a project-based inquiry model (Marx et al., 1997)—the study revealed that the experimental group scored significantly higher than the comparison group on overall scientific literacy. In particular, the experimental class showed a higher scientific literacy level in the nature of
Chapter 2. Background and Issues

Theoretical process, theory-fact differentiation, and recognition of the role of ideas in scientific progress. These three aspects represent challenging problems of understanding in the nature of science (e.g., Carey & Smith, 1993), leading the authors to conclude: “With extended immersion in a Knowledge Building environment, nine and ten year old girls were able to understand that the goal of science is to improve available explanations of phenomena, rather than to accumulate a certain number of facts. They had begun to understand the importance of theory in scientific progress. The focus on ideas—as compared to focus on facts and activities—allows teachers and students to rise above the existing standards of learning and construct deep understanding of phenomena. Science becomes for students an exciting enterprise, rather than a plodding one-thing-after another exercise” (p. 17). It is quite apparent that the knowledge building approach had a significant impact on students’ epistemic beliefs.

Furthermore, similar gains in epistemic beliefs were also uncovered among college-level students when they were using knowledge building in their study of a natural sciences course (Lin & Hong, 2009).

2.3.7 Summary

This section reviews knowledge building literature, covering knowledge building’s key distinctive features, its pedagogy, technology, and its application in science education. In summary, Knowledge Building as a branch of social constructivism distinguishes itself from other constructivist approaches by its focus on collective knowledge creation through distributed cognitive responsibility in a community. Its community-centered approach towards learning reflects a Popperian epistemology that treats knowledge as existing in World 3. This epistemological “bias” guides socio-cognitive processes in Knowledge Building as well as designs of knowledge building environments. Additionally, within the Knowledge Building approach theory building is supported through design-mode thinking, with pedagogy defined by a set of knowledge building principles, rather than
a fixed set of instructional procedures advancing students’ shared understanding like a knowledge-creating organization does. As documented in the literature, the Knowledge Building approach has been shown to advance various aspects of student development. When applied in science education, Knowledge Building has been shown to promote both conceptual change and growth in epistemic beliefs. The Knowledge Building team aims to uncover additional forms of latent productivity.

2.4 Towards an Understanding of Promisingness

In this dissertation, promisingness judgments is discussed within a knowledge building framework/context. This makes perfect sense for a number of reasons. First, knowledge building is deeply concerned with theory building, wherein a significant challenge is to evaluate the promisingness of theories. Second, as discussed above, knowledge building is distinguished by its emphasis on design-mode thinking. Promisingness fits seamlessly with this mode of thinking and contrasts with truthfulness, which is the main concern in belief-mode thinking. Third, the collective evaluation of the promisingness of ideas reflects a deep acknowledgment of the notion of knowledge belonging to a community or existing in World 3. Therefore, the study of promisingness judgments will complement knowledge building research through the exploration of new approaches to advance learning.

This section aims to articulate the concept of promisingness in the knowledge building context. It explains why studying promisingness is important for knowledge building research and draws on extensive literature to make sense of this concept and situate it in educational research.
2.4.1 Why Is Promisingness Important in the Context of Knowledge Building?

Promisingness captures one important aspect of expertise and knowledge creation, and therefore, must be explicitly addressed in knowledge building research and practice. As discussed above, the ability to recognize promisingness distinguishes creative experts from experienced nonexperts (Bereiter & Scardamalia, 1993). Experts know the limits of understanding and skill within their fields. Expert scientists, chess players, and writers were found good at making promisingness judgments of choices (de Groot, 1965; Dunbar, 1995; Gardner, 1994; Simon & Chase, 1973). In a knowledge building classroom with diverse emergent inquiries and flexible participation, a significant challenge is to “help students understand the changing status of their community knowledge and the actions and interactions taking place at the community level” (Zhang, Scardamalia, Reeve, & Messina, 2009, p. 39). This is essentially about helping students make better meaningful promisingness judgments.

The exploration of promisingness is of theoretical significance for advancing knowledge building research. As mentioned above, the distinction between design-mode and belief-mode thinking is essentially differentiation between “promisingness” versus “truthfulness.” In belief mode, activities focus on arguing, gathering and weighing evidence, and further accepting, rejecting, or choosing theories. These activities are all revolving around the truthfulness of ideas. In design mode, people strive to improve ideas by finding weaknesses and repairing them, build new ideas based on existing ones, and embrace a radically different idea when it has higher explanatory power than current ones. As Bereiter (2012b) elaborates, design mode is the mode of idea improvement; the concern in this mode is always about “which is the way ahead,” which is simply another way of saying “which ideas are more promising?” Thus, promisingness judgments are central to any and all knowledge building enterprises.

Investigating students’ promisingness judgments can also contribute to the question
of “whether or not students can take control of their ZPD,” which is a fundamental concern of knowledge building. Scardamalia and Bereiter (1991) studied whether students could identify the educationally most valuable questions from those they generated. In this study, both students and adults were asked to evaluate the educational value of a series of questions on the topic of endangered species, where students already had some basic understanding. Results demonstrated that students identified wonderment questions—questions that reflect curiosity, puzzlement, skepticism, or knowledge-based speculations—as questions worth further investigation. As concluded in this study, “what seems to be required, in order for children successfully to assume executive control in their own zones of proximal development in a classroom setting, is a social process that allows the wisest judgments to work their way forward” (p. 58). Promisingness judgments represent one such “wis[e] judgment.” Designing instructional and technological supports to facilitate young students’ promisingness judgments becomes essential to advancing this line of inquiry in helping students take control of their ZPD.

The study of promisingness represents “design-mode thinking” on knowledge building itself. While knowledge building emphasizes design-mode thinking to promote continual idea improvement, knowledge building itself should be an “improvable idea” as well. Recent research within the knowledge building community is highlighted by an exciting set of studies tackling new approaches to help students reflect and synthesize knowledge building work (M.-H. Chen, Zhang, & Lee, 2013; Zhang, J. Lee, & Wilde, 2012), engage in metadiscourse (Resendes, B. Chen, Acosta, & Scardamalia, 2013), and gain better understanding of their knowledge building through analytics (Oshima, Oshima, & Matsuzawa, 2012; van Aalst et al., 2012). At the 2012 Knowledge Building Summer Institute, Bereiter (2012) posed an important question of “how to make knowledge-building dialogues better,” which spurred rich design-mode thinking towards knowledge building. In his talk, Bereiter proposed a dialogue model that represents a fresh look at knowledge-building discourse. In that model, promisingness evaluation is highlighted as
an important component of knowledge-building discourse. As Bereiter argued,

In complex knowledge creation, single ideas seldom constitute problem solutions and neither do simple combinations of ideas. Substantial further work is normally required to develop the ideas into something that fulfills a knowledge creation goal. Whether a particular idea will prove valuable in the end cannot generally be known with certainty. Therefore a significant challenge in all creative work, in both the fine grain and the large, is to identify promising ideas and to avoid wasting time on or becoming entrapped by unpromising ones (Bereiter & Scardamalia, 1993). Judgments of promisingness are based on knowledge—sometimes principled knowledge but more often an accumulation of episodic and impressionistic knowledge (Bereiter, 2002). Whether there are discourse moves that can increase the quality of promisingness judgments remains to be determined.

Therefore, studying promisingness, one component of knowledge building largely neglected in previous research, represents an essential endeavor to “designerly think” the knowledge building approach.

After establishing the significance of studying promisingness, the rest of this section will be devoted to developing a clearer understanding of this concept. I will start by discussing the literal meaning of the word, then I will make use of analogies to present my view of this concept. After that, I will draw on literature from different fields, in order to present the significance of promisingness and current psychological accounts of it. Finally, I will further situate it in broader educational research and provide a working definition of promisingness for the present dissertation study.

2.4.2 Making Sense of Promisingness

The Literal Meaning

The English word promise was introduced from Latin words prōmissa, prōmissum and prōmittere around 1400AD. For prōmittere: pro- denotes “before”, and mittere means “to put, send.” So the root meaning of a promise is “declaration made about the future, about some act to be done or not done.” The verb “promise” was introduced in 1420 (Dictionary.com, 2011). The use of promising appeared much later, only from 1597
according to Merriam-Webster (2011). Although different dictionaries and thesauri define it differently, two components of meaning are usually recognized, including: (1) for future, and (2) something good or success. For example, promising means “showing signs of future success or excellence,” “likely to turn out well,” or “likely to succeed or yield good results” (Dictionary.com, 2011; Merriam-Webster, 2011; Oxford English Dictionary, 2007b). The meaning of promising is close to hopeful, bright, and likely (WordNet, 2011). The connection with hopeful and bright is consistent with the meaning of “something good in the future,” while the link with likely suggest another important meaning of promising: (3) possibility of success (and failure). This third component seems to be less straightforward, implying that something promising also has a possibility of failure. Since people care more about the good quality of something when describing it as promising, how possible it will turn out to be successful is not usually the first thing to consider.

The word promisingness was first included in Oxford English Dictionary in 1908, but is not defined in most modern dictionaries, including popular ones such as Merriam-Webster. Oxford English Dictionary (2007a, 3rd edition) defines promisingness as the quality of being promising, suggesting that the meaning of promisingness is close to that of promising. Bereiter and Scardamalia (Bereiter & Scardamalia, 1993) coined the term “promisingness” within the context of creative expertise. They regard the knowledge of promisingness as the guide to creative efforts, where to achieve creative results is always a chancy business and involves extensive risk-taking. In the scenario of achieving a creative knowledge goal, promisingness becomes more important than other features such as interestingness and originality. The meaning of promisingness in their account covers the three constructs discussed above, i.e., for future, something good or success, and probability.
Darwin’s Evolution Tree

Analyses play important roles in creative work (Dunbar & Blanchette, 2001; Holyoak & Thagard, 1997; Thagard, 2011), especially in “knowledge-poor” circumstances (Bereiter, 2009). Since little is known about promisingness, analogies to other concepts may help to sharpen our understanding of it. Among many possible analogies, “the struggle of life in nature” provides an interesting scenario for advancing our understanding of promisingness.

From the moment of publication of *On the Origin of Species* in 1859, Charles Darwin’s fundamental idea of natural selection has inspired intensive reactions from fierce condemnation to ecstatic allegiance (Dennett, 1995). His theory was to explain two dimensions of the phenomena of living things—adaptation and diversity—which have been intensively discussed by naturalists at his time (Mayr, 1982). *Natural selection*, as defined by Darwin, is the “principle by which each slight variation of a trait, if useful, is preserved” (Darwin, 1859, p. 61). According to Darwin, individuals with variations of a trait that help them become best adapted to their environments are more likely to survive, reproduce, and maintain those winning traits in their offspring, while others with unfavorable variations would become extinct. As long as there is some variation between them, there will be an inevitable selection of individuals with the most advantageous variations. This is one possible explanation of how the process of “descending with modification” could occur.

Darwin’s ambition was to apply this vision to all walks of life, in order to prove that the great variety of life on earth have all descended—with modifications—from a common ancestor; that is, life on Earth has been generated over billions of years in a single branching tree—the *Tree of Life* (Darwin, 1872, pp. 104-105). In this tree, see Figure 2.3, each new species springs from the parent tree like a shoot. These shoots branch and divide, and then divide themselves, and so on. Some branches die out, while others keep developing. The trunk is the ancient common ancestor from which all animals
Figure 2.3: Darwin’s tree of life, which is called Design Space by Dennett (1995). The graph plots the time-line trajectories of all the things that have lived on this planet, in very low resolution from bottom to top. In particular, an organism’s time line begins when it is born and stops when it dies. After the Earth was formed about 4.5 billion years ago, the first life forms—the simplest single-celled organisms known as *prokaryotes*—appeared around 3.5 billion years ago. After about 2 billion years, a major revolution happened, creating *eukaryotes*—cells with nuclei and other specialized internal bodies. After another 700 million years or so, another revolution occurred, bringing about the first multicelled organisms. From then the pace of change picked up, creating ferns, flowers, insects, reptiles, birds, and mammals. Adapted from Dennett (1995, p. 89).

According to Darwin’s theory, features of living organisms provide a “design space” which produces infinite design possibilities for diversity. In the design space of a single species, design is constantly revised over time, bringing new designs to its diversity. This allows for many directions in which a species could evolve. However, depending on the environment and a specific crunch time of life struggle (e.g., a period of climate change or food scarcity), some directions are more promising than others. As a result, offspring from more promising branches will thrive, and others from less promising branches will die. Hence, promisingness corresponds prominently with this magnificent Tree of Life. In more detail:
1. The promisingness of a mutation in a species is defined by the interplay between environmental factors (such as resources, weather and diseases) and the features of the mutation (e.g., longer beaks, more complex eyes, thicker feathers, etc.).

2. The design space has a high rate of failure, presented by billions of failed “design experiments” or dead-end branches on the Tree of Life. Obviously, promising mutations come with unpromising ones.

3. Successful mutations can only be crowned retrospectively (Dennett, 1995). We cannot know until many generations later whether or not a new branch wins.

4. Equally, no matter how promising a mutation of an individual is, its success depends not so much on its own genetic “makeup,” but more on what happens to its subsequent generations, if any.

5. Last but not least, sexual reproduction brings a remarkable new change to the game, by giving each offspring its own unique sequences of DNA. This brings more diversity to the design space, making promising mutations emerge more frequently, thereby boosting the process of natural selection and evolution.

The Darwinian perspective has not only influenced areas such as zoology and botany, but also domains like philosophy and history (Seward, 1909). Meaningful analogies could be made between the Tree of Life in the history of evolution and the “Tree of Ideas” in the human history of innovation. While on the Tree of Life diversity of design allows promising mutations to emerge and eventually be selected by nature, occurrences of innovative ideas in human society also requires diversity, connections, and mating (S. Johnson, 2010). For example, Darwin’s idea of natural selection itself was an “offspring” of earlier ideas such as adaptation, diversity of life, and Malthusian vision of population (Dennett, 1995; Montgomery, 1988). While there were ideas like natural selection that survived in fierce competition, hundreds of thousands of ideas in human history became reproductively isolated and eventually extinct, just like those dead-ends on the Tree of Life. On this much younger yet not necessarily less vibrant Tree of Ideas, promisingness
tends to share those five characteristics highlighted in the Tree of Life:

1. The promisingness of an idea is defined by the interplay between the multi-dimensionality of its features and the socio-cultural environment it emerges from.

2. Promising ideas co-emerge with unpromising ones. Some ideas sustain, while others die out.

3. The promisingness judgment of an idea is a risky endeavor. While people can tag an idea as promising, they cannot be sure whether it will eventually succeed. So the evaluation of a promisingness judgment (i.e., “judgment of judgment”) can only be done retrospectively.

4. No matter how promising an idea seems, its success depends on investment of effort in further improving it.

5. Communication and collaboration, which bring ideas together for “mating,” can help produce more promising ideas and accelerate knowledge advancement.

In knowledge building, Hong and Sullivan (2009) propose an evolutionary view of idea improvement. For them, ideas are improved in two dimensions: depth and breadth. Improving the depth of ideas involves idea co-elaboration, whereas improving the width depends on idea diversification. Sustained idea development needs both, which may initiate a self-organizing process involving the development of both depth and breadth. As Hong, Scardamalia, and Zhang (2010) point out,

Ideas, once generated, have a public life to support the process of continual improvement. But this does not imply that all ideas will be transformed equally. Depending on the dynamics of a network, some ideas may be connected, elaborated and synthesized more intensively than others. Stated differently, once generated and contributed to a community space, ideas may take very different evolutionary courses and be worked on in different knowledge networks. (p. 9)

Although they explicitly mentioned that not all ideas are developed equally, what remains implicit in their argument is the recognition of promisingness: how any idea on
the Tree of Ideas gets picked up in the first place for any form of further development. As reflected in studies of the history of science, “[s]cientific progress is not a matter of getting closer to the truth; it is a matter of improving on existing knowledge” (Bereiter, Scardamalia, et al., 1997, p. 331). When “pursuit of progress” triumphs “pursuit of truth,” promisingness provides the best guidance for the pursuit of idea improvement, and ultimate knowledge building.

The Walking Tree

Besides Darwin’s tree of life, there is another kind of tree that may help us understand promisingness. In Resnick’s (2003) discussion of ecological thinking, he describes a species of palm tree living in the rain forest of Costa Rica—the walking tree. According to rain-forest guides, the walking tree could slowly walk from one location to another. How does the tree actually walk? One popular explanation attributes this phenomenon to the search for good soil by the roots.² The roots of the tree act as a type of evaluation system of soil. If there is good soil on one side, the roots on that side will grow deeply and hold firmly, giving birth to new roots around that area. If the soil on the other side is poor, the roots on that side will become shallow and weak and may gradually shrink or die out. In this way, the whole tree could gradually pull its roots from the weak side to the strong side. When the roots find even better soil in another direction, the whole tree will move again. Resnick summarizes the principle guiding the actions of the walking tree as a TREE strategy (Resnick, 2003, p. 43):

- **Test Randomly** – send out roots in all directions
- **Evaluate** – determine which roots find the best soil
- **Elect** – choose which direction to move, based on the information from the roots

²There are apparently competing explanations for this phenomenon. Another explanation provided by journalist Sherry Seethaler, which is shared by a number of online videos and documents, think the tree slowly ‘walks’ from shade to sunlight by growing new roots toward the light, rather than good soil (Seethaler, 2010).
As he explains, the walking tree executes this strategy over and over; as it moves, it continually sends out new roots to search the area around its new location. Over time, it moves in the direction of better soil. Of course, the walking tree does not actually “choose” or “decide” which way to move, as a person would. But it is useful to think of the tree as executing a type of strategy or algorithm.

The actions of testing, evaluating, and electing carried out by the walking tree is an interesting thinking model of promisingness evaluation. As a tree, the overarching goal is maintain a best condition for growth. It needs better soil (and maybe better sunshine as well). The accomplishment of this goal rests on the “shoulders” of its roots. The roots reach out to test quality of soil. They aggregate testing results from all roots, evaluate them together, and elect the best direction to move. After the election is made, more energy and resources will be invested in that area, encouraging more roots to grow in the elected direction. So the tests are not random anymore, but are biased towards identified promising directions, because more, stronger roots will grow in the elected area with richer soil. For the walking tree, its roots collectively decide which direction to go. Compared to branches on the Darwin’s tree, the roots of the walking tree is enjoying a lot of agency and control over the overarching goal. The fitness of a walking tree is not passively determined by the environment; it is a result of self-organization among all roots.

The model of the walking tree helps us conceptualize promisingness judgments, especially in a community-based context, and links it to the concept of self-organization (Kauffman, 1993), especially in the context of conceptual development (Bereiter & Scardamalia, 2013). In a knowledge building community, idea improvement is a community enterprise, so promisingness judgments should also be conducted collectively. When producing and improving ideas, one essential cognitive responsibility for community members is to test promisingness of ideas. Different from testing soil quality, tests in the knowledge building context are done against a certain set of criteria embedded in schemas
(see Section 2.2.1) and the results will not become manifest immediately. However, tests would provide some kind of indices of promisingness of a direction. Then the community will bring tests by all community members together and collectively decide the most promising direction to invest their resources in. A new round of idea development and promisingness judgments will begin, focusing on the newly identified directions of development. Thus, in this model of promisingness, tests are not done randomly, but responsively. The TREE strategy here in promisingness judgments then includes:

- **Test Responsively** – test newly developed ideas, especially those produced in directions identified in the last round of promisingness judgments
- **Evaluate** – determine which new directions may produce the greatest idea development
- **Elect** – choose which directions to follow, based on the collective decisions made by all community members

In summary, while the analogy with the Tree of Life helps us think the role of promisingness in knowledge building, the walking tree helps us conceptualize how promisingness judgments actually work. With the conceptual understanding established by analogies, the next section will discuss promisingness judgments in creative processes, as an effort to further elaborate its significance before developing a conceptual model of promisingness judgments.

### 2.4.3 Promisingness in Creative Processes

**Promisingness Judgments by Nobel Laureates**

I think, we almost felt at times that there was almost a hand guiding us. Because we would go from one step to the next, and somehow we would know which was the right way to go. And I really can’t tell how we knew that, how we knew that it was necessary to move ahead.

Above is an excerpt from Michael S. Brown, Nobel laureate in medicine, 1985, when he was discussing “scientific intuition” with other fellow laureates at the *Science and
Man roundtable after that year’s Nobel Prize ceremony. According to his point, he could always find the right direction to move forward in his work, even though he could not explain how.

A similar feeling of direction was expressed by Albert Einstein, Nobel laureate in physics, 1921, when discussing with Max Wertheimer the development of the theory of relativity (Max Wertheimer & Michael Wertheimer, 1959):

[D]uring all those years there was the feeling of direction, of going straight toward something concrete. It is, of course, very hard to express that feeling in words; but it was decidedly the case, and clearly to be distinguished from later considerations about the rational form of the solution. (p. 228)

The “sense of direction” described by Einstein is essentially promisingness judgment—the act of distinguishing the direction towards the most promising solution from an array of alternatives. It depends on feelings and intuition, as Einstein explains, or upon a “guiding hand” as described by Michael Brown, all of which are inarticulable and different from rational thinking.

Arthur L. Schwalow, Nobel laureate in physics, 1981, also mentioned a similar feeling (Shavinina, 2004):

[Y]ou store in your mind a feeling for a magnitude of things, how big things really are, so you’ll get a feeling whether something will go, or not. (p. 248)

The notion of magnitude might be an important criterion of promisingness judgment. It means they feel the direction they choose might bring about something of consequence—something that could solve a big problem, or substantially change the way we think. In other words, they have a strong capacity in recognizing significant ideas.

At the same time, Nobel laureates are also able to differentiate between “good” and “bad” ideas (Csikszentmihalyi, 1996). As Manfred Eigen, Nobel laureate in chemistry, 1967, pointed out,

The only difference between Nobel laureates and their less creative colleagues was that they could tell whether a problem was soluble or not, and this saved enormous amounts of time in addition to many false starts.
Likewise, at Linus Pauling’s (Nobel laureate in chemistry, 1954) sixtieth birthday celebration, a student asked him, “Dr. Pauling, how does one go about having good ideas?” He replied, “You have a lot of ideas and throw away the bad ones.” Thus, being productive in knowledge creation is not much about thinking creatively, but judging wisely. Similarly, George Stigler, Nobel laureate in economics, 1982, claimed:

I consider that I have good intuition and good judgment on what problems are worth pursuing and what lines of work are worth doing. I used to say (and I think this was bragging) that whereas most scholars have ideas which do not pan out more than, say, 4 percent of the time, mine come through maybe 80 percent of the time.

The contrast between good and bad, according to these Nobel laureates, relates to whether an idea will work out eventually. Therefore, creative individuals have strong sense about the probability of whether one idea would be successful. This feature of “odds of success” for an idea is different from “magnitude” mentioned above, which is essentially about the potential impact of an idea if it becomes successful. These two aspects come together to highlight two fundamental constructs of promisingness.

At this point, it is very clear that many Nobel laureates make judgments in terms of promisingness—in terms of “magnitude of the problem” and “odds of success”—and they’re usually quite good at it. While their less creative counterparts would unknowingly spend a lot of time on false starts, Nobel laureates use their skill of making quality judgments to their advantage by saving their time for problems worth pursuing. This is what makes promisingness judgments important in creative problem-solving.

**Promisingness in the Sciences**

Whether it is a scientist planning the next experiment in a research program or a graduate student choosing a thesis topic, evaluation must be made about what will turn out to be most fruitful in an uncertain future. In the history of science, scientists (Nobel laureates or not) are often confronted with “knowledge-poor” circumstances, where principled
knowledge about that problem space is scant (Bereiter, 2009). To achieve a creative goal, they have to cope with many competing ideas that emerge at the same time—usually in their preliminary forms—and make choices among them, within a framework of uncertainty. In this case, a significant challenge is to identify promising ideas that commit scientists to the most fruitful course of action while delaying, or even eliminating, other alternatives.

In Csikszentmihalyi’s (1996) study of creative individuals, he recognized a step of evaluation after an insight is gained in the creative process. In particular, his model of the creative process is composed of five steps: (1) preparation—becoming immersed in a set of problems; (2) incubation—ideas getting connected, oftentimes unconsciously by the creative individuals; (3) insight—bringing the pieces of the puzzle together; (4) evaluation—deciding whether the gained insight is really novel and worth pursuing; and (5) elaboration—strict validation processes. In this model, the evaluation step is absolutely critical because it decides whether the insight is valuable and worth further investment of resources. This step of evaluation is essentially concerned with promisingness of newly gained insights.

Some other researchers thought the evaluation of promisingness would happen much earlier—before an insight is actually formed. For instance, in Dunbar’s (1995) study of scientific reasoning in real-world laboratories, he found that scientists tended to evaluate their projects in terms of risk and promisingness before launching them; scientists were more keen to work on promising projects that had the prospect of making important discoveries despite the fact that they may have also had high risk of failure. In explaining the creative process, Gardner (1994) raised attention to the step of using intuition in order to detect an anomaly or a discrepancy, which happens after “business as usual” when working in a specialized domain. Promisingness, as he explained, is a special feature of a discrepant element that makes it stand out, inspires the individual to invest efforts in making sense of it and its lack of consistency with the established domain, and
eventually guides the person to outstanding breakthroughs. The “business as usual” step for Gardner is equivalent to the preparation and incubation steps in Csikszentmihalyi’s model. However, Gardner contended that the promisingness evaluation step happens before any “local-coherence,” which is akin to the step of insight for Csikszentmihalyi, is achieved. Promisingness is playing an even more essential role to elevate insights latent in the creative process.

Gardner’s thoughts are also concerned with the question of underlying constructs of promisingness. Here, he did not attempt to explain what might make a discrepant element standing out among others. But he does connect it to the notion of local-coherence, which is a concept related to the feeling of “beauty” mentioned by Nobel laureates in the previous section; when people arrive at an idea that can coherently explain a puzzle, they will find it beautiful. So the “incredible feeling of beauty” and the desire for elegant solutions might be inherent in the pursuit of coherence. Local coherence, then, could be another unconscious criterion of promisingness judgments. In other words, the reason that an idea could be considered promising is that it may help one achieve local coherence in a problem space.

In Beveridge’s (1950) *The Art of Scientific Investigation*, he discussed the concept “scientific taste.” Building on work by researchers such as Hadamard, Dale, and W. Ostwald, he proposed that in science there is a thing called taste on which scientists base their personal judgments—just like there is a literary taste and an artistic taste for writers and artists, respectively. As he argued,

> Taste can perhaps best be described as a sense of beauty or aesthetic sensibility, and it may be reliable or not, depending on the individual. Anyone who has it simply feels in his mind that a particular line of work is of interest for its own sake and worth following, perhaps without knowing why. How reliable one’s feelings are can be determined only by the results. The concept of scientific taste may be explained in another way by saying that the person who possesses the flair for choosing profitable lines of investigation is able to see further whether the work is leading than are other people, because he has the habit of using his imagination to look far ahead instead of restricting his thinking to established knowledge and the immediate problem... In research,
taste plays an important part in choosing profitable subjects for investigation, in recognising promising clues, in intuition, in deciding on a course of action where there are few facts with which to reason, in discarding hypotheses that require too many modifications and in forming an opinion on new discoveries before the evidence is decisive. (pp. 78-79)

The concept of scientific taste discussed here is essentially about scientists’ sense of promisingness. Based on the discussion above, promisingness is widely supported through the reported experiences of creative individuals such as the aforementioned Nobel laureates. For experts like Einstein, one outstanding promising direction is the one pointing towards breakthroughs, even though the richness of it will not be manifested until the breakthroughs are finally achieved. Such a feeling of promising direction, which is usually more accessible for people with rich experience working in a domain (Bereiter & Scardamalia, 1993), plays a distinctive role in creative processes. Thus, the capability of recognizing promisingness, as discussed in these studies, is crucial in scientific inquiry.

**Promisingness in Other Fields**

Promisingness judgments are not only evident in scientific laboratories, but also in many other fields and professions that involve creative processes. In de Groot’s (1965) classic work on chess play, he referred to a feeling of promisingness that guided chess masters’ exploration of lines of play. As his study reveals, chess grandmasters do not necessarily consider more options than experienced chess players; they simply think of better possible moves. Accordingly, what distinguishes masters from experienced players is the ability to recognize promising moves directly in their play.

In engineering design, designers are often faced with “wicked problems” (Buchanan, 1992), which require them to make design decisions that can account for a wide range of perspectives across disciplines (Pahl, Wallace, & Blessing, 2007). While there are usually a set of design axioms to follow, the real difficulty in solving these problems often lies upon directly identifying the most fruitful approaches in complex situations,
rather than analytically identifying and evaluating alternative courses of action (Schunn, McGregor, & Saner, 2005). As shown in research on expertise in ill-defined problem-solving, experts do not necessarily know more strategies than nonexperts, but rather, they excel in choosing more appropriate strategies in the same given circumstances (Schunn et al., 2005).

In competitive sports, players usually need to make real-time evaluations based on current information intake, and act according to the most promising moves that emerge intuitively in their minds (J. Johnson, 2006; Klein, 2008; Lehrer, 2010; Zsambok & Klein, 1997).

In fine arts, painters make brushstrokes on the promise of advancing the artistic goal of the painting, which was conceived as a whole conceived on the basis of an idea or image judged by the painter to be promising. As articulated by a Colombian artist, Fernando Botero, when explaining his famous use of proportionally exaggerated or “fat” figures, “an artist is attracted to certain kinds of form without knowing why; you adopt a position intuitively and only later attempt to rationalize or even justify it.”

In music composition, expert composers consider additional dimensions in compositional decision-making even before a score is performed, making promisingness-sharing between expert composers and students a fruitful teaching strategy (Love & Barrett, 2012). In improvisational theater performance, the actor can choose from a wide range of moves at each point in the improvisation; each turn is unpredictable and novel, which in its accumulated entirety results in a collaboratively created, novel performance (Sawyer, 2003). In this context, actors are constantly evaluating the promisingness of possible turns in order to choose the most promising ones for propelling the overall dramatic frame forward.

The same story can be told of the creative writer, chemist, or engineer. To summarize, the evaluation of promisingness, regardless of its rare appearance in the literature, is integral to decision-making in creative processes of many kinds and plays a distinctive

---

3Original source is unknown. Quote from: http://en.wikipedia.org/wiki/Fernando_Botero
role in steering creation and innovation.

2.4.4 Psychological Accounts of Promisingness Judgments

Although the ability to identify promising ideas is essential for creative work with ideas, the process of making promisingness judgments remains largely unexplored. Among a few scholars recognizing promisingness as a concept, even fewer of them have attempted to explain how the evaluation of promisingness work psychologically.

Treating the capability of recognizing promisingness as a key component of creative expertise, Bereiter and Scardamalia (1993) propose that promisingness judgments are guided by impressionistic knowledge, a distinctive type of knowledge in the form of intuitions, hunches and feelings. Impressionistic knowledge can be described as an extremely vague, implicit understanding consisting of attitudes and intuitions about things in various contexts (Bereiter, 2002b). In many circumstances, feelings and impressions can offer us guidance while reason and evidence cannot. For example, sometimes, we have a feeling that a direction could lead to success, but we cannot figure out the reason why we have this feeling nor explain why the evidence at our hands run contrary to this feeling. Thus, although feelings, intuitions and impressions are not typically considered official types of knowledge per se (in comparison to the widely recognized “declarative” knowledge and “procedural” knowledge), they could considerably influence our actions in a reliable, and in some cases, irreplaceable way. Promisingness judgments, as Bereiter (2002b) argues, depend on impressionistic knowledge in the form of hunches and feelings, or in other words, intuitive thinking.

In the field of judgment and decision making, it is widely accepted that intuition and reasoning (also referred to as rational, analytic, or deliberate thinking) play distinctive roles in judgment (Chaiken & Trope, 1999; Epstein, 1994; Hammond, 1999; Hogarth, 2001; Jacoby, 1991, 1996; Myers, 2002). In this area, Stanovich and West (2002) propose a two-system model, labeling intuition and reasoning as System 1 and System 2,
respectively. The operations of System 1 (i.e., intuition) are usually automatic, parallel, effortless, associative, implicit, and emotional, whereas the operations of System 2 (i.e., reasoning) are slower, serial, effortful, more likely to be consciously monitored and deliberately controlled. According to the authors, in some circumstances intuition is favored, so that impressions of the attributes of an object are generated through System 1 based on information from current stimulation and/or long-term memory. In other cases, when judgments are more intentional and explicit, System 2 becomes more dominant, so that impressions generated by intuition may further get modified by reasoning.

Contrary to rational processes, which cannot work simultaneously and instead tend to disrupt each other (D. A. Norman & Bobrow, 1975), intuitive thoughts are much more accessible (Kahneman, 1973, 2003; Pashler, 1998). This gives intuitive thinking a certain advantage over rational thinking because it can operate in the background and be only marginally constrained by cognitive capacity. By studying fire ground commanders, military officers, chess players, and many other professionals working in high-pressured decision-making positions, Klein (1993, 2008) came up with a model of how experienced people can make rapid decisions, called the Recognition-Primed Decision (RPD). This model reduces decision-making to three types of cases: the simplest case is one in which the situation is recognized and the obvious option is implemented; a more complex case is one in which the decision-maker performs some conscious evaluation of the decision option before implementing it; and the most complex case is one in which the intuitively recognized option reveals flaws and needs further information for modification before it can be implemented. As several studies show, experienced professionals do not approach rapid decision-making situations by rationally comparing possible options, but instead, carry out the first course of action that intuitively comes to their minds (Klein, 1999; Lipshitz, Klein, Orasanu, & Salas, 2001). In this model, experience is an extremely important determinant of which case to follow. Experienced people usually could make their decisions by recognition; however, if one’s experience is scant, one needs to turn to a more
complex model, in which an analytical approach—rather than the intuitive approach—is taking control. These studies of decision-making shed light on our understanding of promisingness judgments.

Promisingness judgments can also be possibly affected by other factors related to emotion and affect, as they are undoubtedly associated with intuition (Bolte, Goschke, & Kuhl, 2003; Simon, 1987). Research has found that even in contexts where creativity is espoused as a desired goal, people often end up rejecting creative ideas because of their implicit bias against them. In some cases, such bias can be attributed to people’s level of comfort with uncertainty. As one study shows, when participants experience uncertainty, they are more likely to show a negative bias against creativity (Mueller, Melwani, & Goncalo, 2012). This bias against creativity, by extension, is likely to interfere with people’s ability to recognize creative or promising ideas. Combined with broader research revealing the linkages between emotion and creative processes (e.g., Baas, De Dreu, & Nijstad, 2008; Fong, 2006; J. D. Mayer & Salovey, 1995), there is little doubt that promisingness judgments are connected to emotion, mood, and affect.

It should be noted that studying psychological foundations of promisingness judgments is an independent thesis of research in its own right and is not the focus of the present dissertation research. The review of psychological literature here was nothing more ambitious than informing designs for promisingness judgments in knowledge building context.

2.4.5 To Situate Promisingness in Education

If promisingness judgments play an important role in creative processes, they should have a legitimate place in “education for knowledge creation.” In a “knowledge-creation metaphor of education in a knowledge society,” Paavola, Lipponen, and Hakkarainen (2004) propose that education must go beyond teaching pure propositional and conceptual knowledge and place a larger emphasis on hidden or tacit knowledge. Meanwhile,
advocates of “teaching for wisdom” attempt to find ways to nurture students’ capacities in applying tacit knowledge toward the achievement of a common goal determined by themselves and others (Sternberg, 2001). The capacity of making promisingness judgments, which is one form of tacit knowledge important for knowledge creation (Bereiter, 2002b; Bereiter & Scardamalia, 1993), is a type of teachable wisdom. Like other types of wisdom, it is much more difficult to develop and assess than is the kind of knowledge that can be readily measured through standardized tests. For education in a knowledge-creating society, an important question remains: Should the capability of evaluating promisingness be recognized as a valuable competency and be integrated as a fundamental component in the current education agenda in order to prepare students for the knowledge age?

The attempt to advocate promisingness judgments in schooling is in line with a variety of efforts to rethink and enrich what is currently being taught in schools. Learning is still a paradox (Bereiter, 1985). Scardamalia and Bereiter (1994) raise the concern that schooling deals with only the visible parts of knowledge (formal knowledge and demonstrable skills), but not the informal or tacit forms of knowledge—both the kind that students bring in with them and the kind that they will need in order to contribute to a knowledge society. This gap results in acquisition of inert knowledge that fails to inform thought and behavior. One line of work to address this issue is to cultivate expertlike learners (Bereiter & Scardamalia, 1993), or to teach for expertise (Björklund & Eloranta, 2005; Sternberg, 2003). Sternberg (2003) argues that “we need to identify expertise in a way that is closely aligned with the way experts are identified in the disciplines students study” (p. 5). In his framework of “successful intelligence,” he highlights three dimensions of teaching, which includes analytic thinking, creative thinking, and practical thinking, to help children think in ways characteristic of experts in a variety of disciplines. In addition to this framework, there is another important component of expertise that encompasses reflective thinking, meta-cognition, and more broadly, the capability to take a meta-level perspective of one’s activities and one’s relation with the
world. This type of expertise involves active, persistent, and careful consideration of any belief or supposed form of knowledge in light of the grounds that support it (Dewey, 1933). It could also take the form of reflective judgments (P. M. King & Kitchener, 2004b), cognitive monitoring and metacognitive skills (Flavell, 1979; D. Kuhn, 2000; R. E. Mayer, 1998), ecological thinking (Resnick, 2003), and epistemic cognition (Carey & Smith, 1993; Sandoval, 2005). These functions warrant our attention and play an important role in learning; they have been promoted by educators. The above studies have greatly expanded our understanding of education. They also encourage emergent efforts to uncover new areas of teaching ignored by current education agenda. The study of promisingness judgments is one example of such studies. In particular, the evaluation of promisingness is associated with, and overlaps with these aforementioned areas. It represents an important aspect of the mental processes that are evident in human learning but largely neglected in education (Bereiter, 1985). The pursuit of understanding promisingness judgments will substantially contribute to the broader research agenda of rethinking learning and education.

Although promisingness judgments play an essential role in creative expertise, education at all levels by and large ignores students’ capability in recognizing promising ideas. In constructivist educational approaches, where students have a say in determining which questions they will investigate and how they will investigate them (Duffy & Jonassen, 1992), judgments of promisingness become important so as to avoid going down blind alleys (Bickhard & Campbell, 1996) and to direct the investment of effort in ideas that can be developed into coherent explanations (Thagard, 2000). However, there is no evidence that promisingness is even brought up as an issue in typical constructivist learning activities. Common school practices usually help students avoid unpromising directions by putting the “steering wheel” of inquiry in the hands of teachers. Learning activities are usually structured (Kollar, Fischer, & Slotta, 2007; Mäkitalo-Siegl, Kohnle, & Fischer, 2011) so that students do not spend a great deal of time with ideas considered as
“unpromising,” and thus, it is up to the teacher to recognize and help students overcome misconceptions that block learning progress.

The alternative offered by Knowledge Building is to invite students to take collective responsibility of their own learning (Scardamalia, 2002; Scardamalia & Bereiter, 2003). In Knowledge Building, continual idea improvement is central, and cognitive responsibility around this goal, such as setting goals, monitoring progress, and deciding directions, rest greatly on the shoulders of students. Within this context, promisingness becomes fundamentally relevant to the successful functioning of a knowledge building community. The evaluation of promisingness is an essential element that distinguishes “design-mode” thinking, which drives innovations in real-world knowledge-creating organizations, from “belief-mode” thinking, which is embraced by most educational models (Bereiter & Scardamalia, 2003). Thus, in knowledge building we need to engage students in practicing decision-making on their own and nurture their capability in making promisingness judgments in their day-to-day schoolwork. This raises the question, however, of whether young students are capable of making useful judgments of promisingness. And for educators, what different course should we put students on in order to develop this capability?

2.4.6 Summary

This section is of significant weight in this dissertation because it attempts to articulate the concept of promisingness judgments. Promisingness figures widely in creative processes in a variety of fields, including science, arts, economics, design, and medicine, and is accordingly crucial for knowledge building as a pedagogy for knowledge creation. As a matter of fact, whether a knowledge creating effort will become successful depends on whether promisingness is successfully recognized.

The psychological process involved in promisingness judgments has not been empirically studied. It is conjectured to be based on impressionistic knowledge, which is largely
composed of impressions, feelings, and emotions. Based on the current literature surrounding decision-making and judgment, promisingness judgments are likely to rely on an interactive system involving both the intuitive and analytical thinking.

Regardless of the current lack of a consensus in its psychological interpretation, studying promisingness judgments is well-situated in teaching for wisdom, tacit knowledge, and expertise and is of significance in the current education agenda. Rather than becoming entangled on the psychological explanation of promisingness judgments, this dissertation research will focus on designing and developing pedagogical and technological supports to set students on the path toward developing their ability in making promisingness judgments within creative contexts.

In the next section, I will explore the issue of technological supports for promisingness. I will discuss the limitations of current designs of knowledge-building environments. Informed by the understanding acquired in this section, I will then present key features of tools to scaffold promisingness judgments.

## 2.5 Tool Support for Promisingness

Despite its prevalence in creative knowledge processes, promisingness is rarely supported by tools currently available for knowledge work. Threaded discussion, which still dominates almost all types of online communication and collaboration, provides little support for promisingness. When used to support virtual learning communities, threaded discussion can supplement or replace face-to-face classroom interactions, enabling asynchronous exchanges (Harasim, 1987) and higher level of peer interactions (Hiltz, 1986). However, previous research has highlighted that the design of threaded discussion allows online habits of participants to adversely affect the lifespan of some threads; specifically, the overwhelming focus on unread notes hastens the death of some threads regardless of their content (Hewitt, 2005). As a result, promising ideas can be easily trapped in inactive
threads and eventually die in threaded discussion. Recent development efforts, such as Discourse,⁴ are attempting to “reboot” threaded discussion software. Nonetheless, such efforts are usually driven by the urge to renovate technical designs (e.g., adding notifications when someone gets mentioned, expanding embedded links, and displaying real-time metrics of posts), with the conceptual design of threaded discussion remaining intact. In this case, even though some new features offered by Discourse, e.g., post metrics (see Figure 2.4), could serve as indicators of an idea’s promisingness, the renovated threaded discussion tool still falls short in sustaining continual work with ideas after they rise to the top. After all, promisingness judgment is not a one-shot competition among ideas; rather, it requires continual effort to build increasingly powerful ideas. This notion is apparently missing in threaded discussion tools.

Supports for promisingness are not present in most collaborative learning environ-

---

⁴See http://www.discourse.org/
ments. Besides the threaded discussion software, a variety of tools have been developed within the computer-supported collaborative learning (CSCL) community to support online discussion. Different approaches have risen from this area of work, such as designing representational guidance to reveal conceptual structure of discussion (Suthers, Vatrapu, Medina, Joseph, & Dwyer, 2008) and scaffolding learner communication in specific learning subjects (Stahl, 2009). More relevant to the concept of promisingness, some other CSCL projects have been attempting to bootstrap idea development in collaborative learning. For example, in the Web-based Inquiry Science Environment (WISE, Linn, D. Clark, & Slotta, 2003; Slotta & Linn, 2009), a relatively new functionality called Idea Manager has been implemented to help students manage their ideas and further construct scientific explanations or arguments from them (McElhaney, Matuk, Miller, & Linn, 2012). In this tool, one component named Idea Basket is designed to serve as a persistent repository for student ideas in WISE investigations. The Basket reduces demands on students’ memories and allows them to direct their efforts toward critically examining their ideas. Students add ideas (of up to 150 characters) to the Basket; revise, sort, and tag them; and eventually feed them to an Explanation Builder to build scientific explanations (McElhaney et al., 2012). WISE’s supports for idea generation, management, remix, and election through the Idea Basket provide an interesting design centered on student ideas. However, because of WISE’s unit-based curriculum structure and instructional emphasis on scientific argumentation, the Idea Basket is not intended to support promisingness involving long-stretches of theory building.

In the workplace, tools dedicated to promoting knowledge production abound. Such business software, such as Edistorm, wriidea, IdeaScale, Jive, Kindling, IdeaTorrent, Spigit, and Mindjet Catalyst, are designed to support idea brainstorming, boosting, and implementation in companies. However, these tools may be best depicted as “idea management software,” because the main intention is to manage rather than build ideas. Although some of them may have a taste of promisingness, best revealed by a voting
system that can help “best” ideas rise to the top, little support is provided by these systems to improve or implement ideas emerging to the top. As a result, substantial work is normally done outside of these systems after an idea is rendered promising.

This consideration threaded discussion, collaborative learning environments, and workplace knowledge management tools indicates that in the absence of supports for continual idea development, promisingness is often not raised as an issue, even if certain design elements are available to facilitate promisingness judgments. In contrast to these software tools, knowledge building environments, represented by Knowledge Forum (see Section 2.3.5), are created with affordances for sustained, creative work with ideas (Scardamalia, 2004). As explained by Scardamalia (2003, p. 270), an effective knowledge building environment should have supports “for the formulation of knowledge problems, for preserving ideas and making them accessible as objects of inquiry, for dialogue that is democratic and favorable to idea diversity, for constructive criticism and analysis, for organizing ideas into larger wholes, and for dealing with recognized gaps and shortcomings of ideas.” To afford these supports, Knowledge Forum features a multimedia community knowledge space to which participants contribute theories, working models, plans, evidence, and so forth in the form of notes (Scardamalia, 2004). More importantly, Knowledge Forum is designed with an underlying commitment to the “endless improvability of ideas” that the aforementioned tools lack. Such a commitment is best reflected by the function of “rise-above” notes, which preserve the value of divergent ideas at a time while rise above their incompatibilities (Scardamalia, 2004). As a result of creating rise-aboves, public knowledge could achieve a higher level of explanatory coherence (Thagard, 1989); communities ideas also advance to a more advanced state for further improvement. Therefore, in comparison with other tools mentioned above, knowledge building environments strive for endless improvability of ideas, and accordingly, make promisingness of ideas a much more relevant issue that demands tool supports.

However, the support for promisingness remains implicit in Knowledge Forum, re-
gardless of its natural interest in promoting promisingness. As discussed in Section 2.4.1, promisingness is a cornerstone of knowledge building and ought to be explicitly addressed. Knowledge Forum supports improvable ideas by the ability to review and revise notes, to create rise-aboves, and to publish notes and views to a higher layer (Scardamalia, 2004). It is apparent that these knowledge processes involve the evaluation of promisingness of ideas; in other words, promisingness is woven into processes of theory improvement, rise-above, collective responsibility, and so forth. However, no effort has been made to directly address promisingness—a pivotal epistemic move in knowledge building. Furthermore, recent work in knowledge building to scaffold student metadiscourse, i.e., discourse about discourse, has catalyzed the development of an array of new analytic tools focusing on specific aspects of idea improvement such as contribution types (Resendes, B. Chen, Acosta, & Scardamalia, 2013) and the idea evolution trajectory (Zhang, J. Lee, & Wilde, 2012). Metadiscourse facilitated by these tools also involves the step of recognizing promising contributions in the current community workspace. Nevertheless, promisingness judgments remain tacit, more peripheral, without support for more purposeful, thoughtful coordination. Because of the significance of promisingness in knowledge building, new functionalities designed to directly support promisingness judgments are needed to further advance Knowledge Forum’s capabilities in promoting endless improvability of ideas.

Designs to support promisingness judgments in knowledge building need to go beyond current practice in education and workplace. To achieve this goal, a few important aspects need to be considered. First, new designs have to ensure epistemic agency remains on the side of students. Promisingness judgments in knowledge building are essentially about decision making about the potential of ideas. Teaching students how to make effective decisions calls for effective designs for decision making (Jonassen, 2012). Such designs should provide relevant feedback to empower students to make meaningful decisions rather than having them learning about decision-making. In other words, learners must experience decision-making processes and the consequence of their choices in order to
learn to make good decisions. Therefore, assessment of decision-making results should be integrated into supports for students’ promisingness judgments.

Second, because the essential goal of promisingness judgments is to improve ideas, new designs should be tuned towards continual idea improvement. Researchers have highlighted two directions of idea improvement in knowledge building: depth and breadth (Hong & Sullivan, 2009). To improve the depth of idea requires collaboration between knowledge workers, whereas to improve the breadth of an idea calls for knowledge interactions among ideas or conceptual artifacts. Depending on how ideas are formed and transformed, either direction could be enriching and fruitful. Design for promisingness needs to respond to idea development in both dimensions, to meet needs of transformation in both depth and breadth.

Third, when devising computer support for promisingness, rather than tackling it alone, it could be more fruitful to consider a complex system involving promisingness and other important aspects of knowledge building. For instance, idea development is a self-organizing process (Bereiter & Scardamalia, 2013), so designs for promisingness judgments could consider supporting self-organization around promising ideas, by “link[ing] any idea with any other ideas, for purpose of comment or synthesis” and “to carry on a meta-dialogue, which is dialogue about the main dialogue—about its content, progress, difficulties, and so on” (Bereiter & Scardamalia, 2013, pp. 515-516). By doing so, designs could be more geared towards the creation of rise-aboves in discourse, with promising ideas identified, linkages among ideas more apparent, and the status of dialogue clearer. Thus, by connecting with promisingness these different aspects—self-organization, meta-dialogues, rise-above, and idea connectedness—we will have a better chance to foster high-level emergents in knowledge building. This goal calls for new conceptual frameworks. At the same time, it also requires advanced machine learning techniques because manual analysis is neither feasible nor efficient in this case. Recent work within the CSCL community shows promise of the machine as a more powerful partner in human-machine
collaboration, enabling more complex knowledge practices (McLaren et al., 2007; Rosé et al., 2008) that open up exciting new opportunities.

Finally, when designing technological supports for promisingness, it is important to keep in mind the myth that powerful technology is all that is needed to facilitate promisingness in education. Decades of work in educational technology has shown that instructional support is key to successful use of classroom technologies (e.g., Cuban, 2003). Taking Knowledge Forum for example, teachers with little knowledge about knowledge building principles could use it just like a regular discussion forum; to harness its affordances for knowledge building, proper instructional design and teacher education are needed. Thus, when designing technological supports for promisingness, the surrounding supports for effective knowledge practices were key to implementing those supports, and are elaborated throughout the sections presenting research methods and results.

Bringing these thoughts together, in the process of this dissertation study I have engaged in an iterative process of designing new technologies and knowledge practices to support promisingness judgments in knowledge building. More details of these designs will be discussed in Chapter 3.

2.6 Research Questions

This dissertation research represents the first effort to bring promisingness judgments into classroom practice, aiming to promote this special capability among young students. Because promisingness underlies knowledge building principles, previous knowledge building research has tried to support promisingness, albeit implicitly, through collective responsibility, theory development, rise-above, etc. The current work is a natural extension of previous studies, now focusing directly on the concept of promisingness. Students can only assume epistemic agency if they can live these knowledge building principles and find promising paths through their discourse. However, I see this work barely scratch-
ing the surface of promisingness, especially because the epistemological underpinnings of promisingness and the psychological interpretation of promisingness judgments remain unclear. The goal of this research, therefore, is to create social, cognitive, emotional contexts to uncover new competency students might bring to the challenge of identifying and advancing promising ideas among students.

As the first design study to directly tackle the concept of promisingness, this study focuses on uncovering aspects of promisingness judgments that may be accessible to young students. By developing technological and instructional supports for promisingness judgments, this study attempts to uncover promisingness evaluation as a new competency in the knowledge age. Hence, this dissertation research is more interested in understanding dynamics involved in students’ promisingness judgments than comparing designed classroom interventions with other approaches.

Informed by the reviewed literature from various domains, this study aims to tackle the following research questions:

1. Do young students have awareness of promisingness—defined as knowledge building potential—of their own ideas? What are their intuitive perceptions of the concept of promisingness?
2. How can we raise students’ awareness of promisingness and support them in making promisingness judgments in their knowledge building?
3. How would promisingness judgments influence knowledge-building discourse, at both individual and community levels?
4. To which extent could promisingness judgments facilitate knowledge advancement in a knowledge building community?
5. To which extent could promisingness judgments facilitate personal epistemic beliefs of students?
Chapter 3

Methodology

3.1 Chapter Overview

This methodology chapter begins with an introduction to the design-based research approach that guided the implementation of the promisingness intervention in this dissertation. I then introduce design elements and provide a general overview of three design cycles in this dissertation. Research sites and participants, which varied slightly across three iterations of this dissertation research, are then described. I also present a general overview of data analysis applied in this dissertation, to set the stage for more detailed procedures and analytic methods presented in later chapters.

3.2 Design-Based Research

To scaffold young students’ promisingness judgments in knowledge building it was necessary to devise new pedagogical and technological supports. Because of the novelty of the challenge this work required multiple trials in natural classroom settings, in order to effectively assess and continuously improve these supports. Hence, research methodology incorporated in this dissertation needed to accommodate multiple design cycles for testing and improving classroom innovations for promisingness judgments in multiple
Design-based research, a research methodology widely applied by learning scientists and learning technologists, was used. The rise of design-based research in the learning sciences corresponds to efforts to work in complex, real-world classroom environments, making it impossible to implement controls, as strictly as psychologists are able to do in experimental lab contexts. Recognizing this challenge, Ann Brown (1992) and Allan Collins (1992) introduced “design experiments” to characterize a new methodology, one that acknowledges educational research as a complex system involving multiple factors and emergent properties with factors such as curriculum, teacher, and assessment oftentimes so deeply interconnected that they cannot be independently studied (Bielaczyc & Collins, 2006). Design research accommodates complexity, contextual factors, and analytic techniques to explore learning behaviors (A. L. Brown, 1992; Reiser, 2004; Sterman, 1994). In contrast traditional experimental research aimed at isolating factors for their independent analysis frequently dismiss important factors, thus the need for a more holistic approach (A. L. Brown, 1992).

The terms “design experiments,” “design-research” and “development research” have been used to describe the same methodology (T. Anderson & Shattuck, 2012). The term “design-based research” is preferred by some researchers to avoid confusion with experimental design, with studies of designers, and with trial teaching methods (Hoadley, 2002). In this dissertation, I use design-based research for consistency.

To explicitly distinguish design-based research from traditional psychological experiments, Collins (1999) identified seven major differences between them, focusing on methodological issues including location of research, complexity of variables, focus of research, procedures, and so forth (see Table 3.1).

Underlying these methodological differences between design-based research and well-controlled psychological experimental studies are significant ontological and epistemological differences (Barab & Kirshner, 2001). In particular, it challenges the traditional
<table>
<thead>
<tr>
<th>Category</th>
<th>Psychological Experimentation</th>
<th>Design-Based Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location of research</td>
<td>Conducted in laboratory settings</td>
<td>Occurs in the buzzing, blooming confusion of real-life settings where most learning actually occurs</td>
</tr>
<tr>
<td>Complexity of variables</td>
<td>Frequently involves a single or a couple of dependent variables</td>
<td>Involves multiple dependent variables, including climate variables (e.g., collaboration among learners, available resources), outcome variables (e.g., learning of content, transfer), and system variables (e.g., dissemination, sustainability)</td>
</tr>
<tr>
<td>Focus of research</td>
<td>Focuses on identifying a few variables and holding them constant</td>
<td>Focuses on characterizing the situation in all its complexity, much of which is not now a priori</td>
</tr>
<tr>
<td>Unfolding of procedures</td>
<td>Uses fixed procedures</td>
<td>Involves flexible design revision in which there is a tentative initial set that are revised depending on their success in practice</td>
</tr>
<tr>
<td>Amount of social interaction</td>
<td>Isolates learners to control interaction</td>
<td>Frequently involves complex social interactions with participants sharing ideas, distracting each other, and so on</td>
</tr>
<tr>
<td>Characterizing the findings</td>
<td>Focuses on testing hypothesis</td>
<td>Involves looking at multiple aspects of the design and developing a profile that characterizes the design in practice</td>
</tr>
<tr>
<td>Role of participants</td>
<td>Treats participants as subjects</td>
<td>Involves different participants in the design so as to bring their differing expertise into producing and analyzing the design</td>
</tr>
</tbody>
</table>

*Note. Adapted from Collins (1999).*
view of knowledge as a static structure residing in the individual’s mind and advocates a relatively new perspective that “knowing is a process distributed across the knower, the environment in which knowing occurs, and the activity in which the learner is participating” (p. 5).

More significantly, in my opinion, design-based research distinguishes itself from traditional psychological research in the values it places on sustained innovation in education (Bereiter, 2002a) or ontological innovations (DiSessa & Cobb, 2004). While design-based research distinguishes itself by many methodological features, it should be noted that it is also defined by its usually innovation-oriented goals. In Barab and Squire’s (2004) words,

[D]esign-based research strives to generate and advance a particular set of theoretical constructs that transcend the environmental particulars of the contexts in which they were generated, selected, or refined. This focus on advancing theory grounded in naturalistic contexts sets design-based research apart from laboratory experiments or evaluation research. (p. 5)

Thus, design-based research is essentially an iterative process, with innovations evaluated in natural settings and then further revised to achieve more desirable results. Improvements do not come from design efforts alone, but are grounded on theoretical knowledge in specific learning experiences (T. Anderson & Shattuck, 2012; Edelson, 2002).

While design-based research is a powerful research tool, it brings with it significant challenges. As Collins and colleagues (2004) indicated, there are difficulties arising from the complexity of real-world situations and their resistance to experimental control; the research produces large amounts of data arising from a need to combine ethnographic and quantitative analysis; and the approach gains power from iterative refinements of design. Dede (2004) described methodological challenges due to “under-conceptualized” and “over-methodologized” procedures evident in many design-based research studies.
Under-conceptualization stems from fascination with artifacts and a lack of theoretical foundation; being over-methodologized results in voluminous datasets that are redundant and unnecessary. He also cautioned researchers to make less ambitious claims about design-based research and suggested collective standards for what constitutes quality in this methodology. These challenges, especially the need for collective standards for constituting quality, is also recognized by the design-based research community (Barab & Squire, 2004; The Design-Based Research Collective, 2003). The Design-based Research Collective (2003) stated:

Objectivity, reliability, and validity are all necessary to make design-based research a scientifically sound enterprise, but these qualities are managed in noticeably different ways than in controlled experimentation (e.g. Barab & Kirshner, 2001). (p. 7)

Hence, researchers suggested alternative criteria to ensure quality of design-based research, such as trustworthiness and credibility, instead of using validity and reliability in more traditional psychological studies (Barab & Squire, 2004). Regardless of these challenges, when well-conceptualized and solidly-grounded in theories, design-based research can be conducted with empirical rigor, resulting in research with strong, evidence-based claims (Edelson, 2002).

I designed this dissertation research with these challenges in mind and in light of the overarching goal to design innovative socio-cognitive, emotionally rewarding contexts that might tap into students’ latent competencies for making promisingness judgments. Design improvements are informed by theoretical understanding of Knowledge Building and promisingness. Special attention has been paid to ensure trustworthiness and credibility by applying strategies such as prolonged engagement, triangulation, thick description (Creswell, 2012), and data analytic procedures aimed at uncovering student competences and iterative refinement of procedures and results.
3.3 Overview of Research Plan

3.3.1 Elements of Design

In line with these considerations I focused the following design elements across all design experiments reported in this dissertation:

Technological Supports

To support promisingness judgments in knowledge building discourse, I designed and implemented a new Promising Ideas (PI) tool that was integrated within Knowledge Forum. The goal of this tool was to empower students to select promising ideas from their collective workspace and direct more resources to improving those ideas through subsequent knowledge building, as well as enhance Knowledge Forum’s idea improvement potential. Following design-based research methodology and the principle of real-world testing and evaluation, the PI tool was refined through three distinctive design cycles. Different versions of PI will be elaborated in chapters corresponding to different uses in different research settings.

Knowledge Practices Surrounding Technological Supports

As discussed in Section 2.5, technological supports need to be coupled with proper pedagogical designs to achieve their potential in classroom settings. To support students using PI, efforts were made to design knowledge practices surrounding technological supports, to create enabling social, cognitive, emotional, and cultural contexts for promisingness judgments. Like technological supports, designed knowledge practices have also been tested and revised through three design cycles. Details will be presented in corresponding chapters.
3.3.2 Overview of Design Cycles

To advance these two design elements, three cycles of design experiments were carried out, reported in Studies 1 to 3, Chapters 4 to 6, in this dissertation. Below I provide a brief overview of the three studies:

Study 1, Chapter 4

The first study involved testing PI with students, probing students’ intuitive conception of promisingness, and exploring potentially effective pedagogical designs for promisingness judgments. Key questions for this study included: How would young students, with a considerable amount of experience with knowledge building, perceive the concept of promisingness? Without any kind of intervention, to which extent could young students evaluate promisingness of ideas produced by student knowledge building? Which socio-cognitive configurations could help to situate young students to think about promisingness of ideas?

Study 2, Chapter 5

With insights gained from Study 1, the second study introduced more advanced technological and pedagogical supports for promisingness. It featured a “three-phase experimental intervention” engaging students in making promisingness judgments in their discourse. The impact of promisingness judgments on discourse dynamics and community knowledge advancement was investigated. Guiding research questions included: Is it possible to raise students’ awareness of promisingness and correspondingly their ability to make promisingness judgments regarding their ideas and those of their peers with respect for potential for further idea improvement? How might promisingness judgments influence knowledge-building discourse, at individual, group, and community levels? Can promisingness judgments facilitate knowledge advancement in a knowledge building community?
Study 3, Chapter 6

The final study extended Study 2, with refined tools and pedagogical supports, and further targeted the linkage between promisingness judgments and personal epistemic beliefs. In addition to questions concerned with discourse dynamics and knowledge advancement, research questions in this study included: What is the nature of the relationship between students’ current level of epistemic beliefs and their promisingness judgments? Would practice in making promisingness judgments lead to changes in students’ epistemic beliefs?

3.4 Research Settings

3.4.1 Research Sites

Two different schools were involved in the three design cycles corresponding to the three studies elaborated in Chapters 4 to 6:

School A

The primary research setting was an elementary school, School A, located in downtown Toronto. Founded in 1925, this private school provides specialized education for children, Nursery school to Grade 6 (3-12 years old). It has a mission covering three dimensions of education, including bringing together graduate teacher education, exemplary educational practices, and multidisciplinary research in child development. Its student population comes largely from middle- and upper-middle class families, with a portion of the student population need-based students receiving financial support. Students are from diverse ethnic backgrounds, reflecting both the multiculturalism of the city and the school’s commitment to inclusive educational environments for its students. At the time I conducted my research the school had one class in each grade from Junior Kindergarten
to Grade 4, each with approximately 22 students. Grade 5 and 6 were mixed so there were two Grade 5/6 classes in this school.

Knowledge Building was first introduced into this school in 1990s and came to be used school-wide, from Junior Kindergarten on. Knowledge Forum is typically introduced to students in Grade 1. For over a decade now the school has been recognized as a “Knowledge Building school.” Throughout this time Knowledge Building has operated at each grade level as a “principle-based pedagogy,” implementing core values and principles rather than scripted procedures (Zhang, Hong, et al., 2011). In School A the twelve knowledge building principles defined by Scardamalia (2002) have been treated as pedagogical design parameters to engage students and teachers in sustained idea improvement integral to their day-to-day practice in each classroom of the school. Students are expected to take high-level collective responsibility for advancing their community knowledge, by contributing their real ideas to create collective solutions to authentic problems in their class. In Knowledge Forum their ideas become public “conceptual artifacts” (Bereiter, 2002b) to be improved by the whole community through extensive knowledge-building discourse: Through both face-to-face and computer-mediated interactions students analyze problems, generate new ideas, engage in constructive criticism, make comparisons, engage in metadiscourse, and identify emergent new problems. While Knowledge Forum provides the public space for students’ ideas to be continually improved, regular face-to-face meetings known as “Knowledge Building (KB) talks” represent a powerful contributor to this work. KB talks are typically carried out with students sitting in a circle on the carpet; this intentional design of physical configuration is to promote mutual respect, establish rapport, nurture a feeling of safety to share ideas, and foster idea diversity and symmetric knowledge advancement within a class. Through knowledge-building discourse, ideas are collectively improved through emergent processes including experiments, observations, and constructive use of authoritative sources. Students find many of those sources themselves on the web as they aim to advance their
understanding. They are accustomed to assessing sources critically and using them to support or refine their ideas, rather than use of source material primarily to demonstrate comprehension. Overall, before the present study was carried out knowledge building had become a distinctive culture in this school, which sustained teachers and students in carrying on complex, emergent, innovative knowledge processes leading to a broad range of knowledge advancing capabilities (Zhang, Hong, et al., 2011). This school represented an “optimal research setting” as described by Fischer and Bidell (1997) for identifying cognitive developmental goals and new competencies, and thus, for studying promisingness judgments in particular.

As the major research site, School A was where most of the development and research (the first two studies) took place. When a new technology design was developed, it would be brought to this school’s bi-weekly KB meetings, where teachers, principals, and researchers come together to discuss ongoing knowledge building work in each classroom. Teachers’ insights have played an important role in refinement of the tool, with several functions of the tool originating with them. Thus the work represents a co-design context (Penuel, Roschelle, & Shechtman, 2007). Teacher interests and participation not only advanced technology design but motivated research studies in their classrooms.

School B

In addition to the Toronto school, a K-12 school, School B, participated in the third design cycle of this dissertation. School B is a private school located in the northern suburb of Bogotá, Colombia, with its student population mainly coming from middle- and upper-middle-class families. This school was a bilingual school; all students in the class could speak English fluently and all science lessons were taught in English. In this school there were notably two motivated knowledge building teachers—one head science teacher and one educational technology lead—who had attended the annual Knowledge Building Summer Institutes several times. There were also teachers and students using Knowledge
Forum for Philosophy and Spanish subjects, as well as Teacher Education programs. School B had also participated in the Knowledge Building International Project (KBIP)\(^1\) since 2010, along with colleagues from several regions around the world.

The idea of conducting the third study in School B originated from the motivation of extending promisingness judgments beyond School A, which is regarded as an optimal setting for knowledge building. I was looking to explore the promisingness tools at a site less “optimal” than School A but still having sufficient background experience to allow relatively quick uptake of promisingness work. In 2012 I approached colleagues from Bogota, Colombia—Jane and Finn—who kindly agreed to collaborate with me. Fitting a deeper principle-based knowledge building design into their existing school curriculum was an interesting challenge. We spent three months communicating through emails and Skype meetings to plan details of this study. Receiving travel funding from the School of Graduate Studies at the University of Toronto, I was able to travel to School B for one week of field work, during which time the main part of the third study in this dissertation occurred.

In both schools A and B, students were provided with laptops for use during class time. Each participating class from School A was equipped with 11 MacBooks, with two students sharing one computer. The participating class in School B was equipped with Dell Laptops, with two to three students working on one computer. All classrooms were WiFi-enabled, so the students were free to move around in the room and interact with the teacher or their peers. In all studies, students only worked in school and did not work at home, as far as researchers were aware of.

\(^1\)The Knowledge Building International Project (KBIP) is a knowledge building project between schools in several regions of the world including Québec, the United States, Hong Kong and Catalonia. Website: [http://kbip.co/](http://kbip.co/)
Table 3.2: An Overview of Research Sites and Participants

<table>
<thead>
<tr>
<th>Studies</th>
<th>Research Questions</th>
<th>School/Location</th>
<th>Teachers</th>
<th>Students</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study 1</td>
<td>Awareness of promisingness; different supporting socio-cognitive processes</td>
<td>School A, Toronto</td>
<td>Jessica, Brian</td>
<td>Three Grade 5/6</td>
<td>2009-2011</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>classes</td>
<td></td>
</tr>
<tr>
<td>Study 2</td>
<td>Intuitive understanding; supporting socio-cognitive processes; influence on KB discourse</td>
<td>School A, Toronto</td>
<td>Renee, Danielle</td>
<td>Two Grade 3 classes</td>
<td>2010-2011</td>
</tr>
<tr>
<td>Study 3</td>
<td>Intuitive understanding; supporting socio-cognitive processes; epistemic beliefs</td>
<td>School B, Bogota</td>
<td>Jane, Finn</td>
<td>One Grade 6 class</td>
<td>2013</td>
</tr>
</tbody>
</table>
3.4.2 Participants

This section describes the participants involved in Schools A and B, including teachers and student cohorts. See Table 3.2 for a brief overview.

Teachers

Six teachers, four from School A and two from School B, were directly involved in this study. Brian and Jessica, two Grades 5/6 classes, participated in the first pilot study; Renee and Danielle, teaching Grade 3 in two consecutive years, participated in the second study; Jane and Finn, co-teaching Grade 6 from School B, participated in the third study.

The four teachers from School A had varied experience in knowledge building. Notably, Danielle joined School A for a year through an exchange program; she was officially affiliated with a public school in Toronto District School Board and was new to Knowledge Building and Knowledge Forum. In contrast, the other three teachers had been working at School A for more than three years and all had rich experience in Knowledge Building.

I first met each of these teachers at their bi-weekly KB meetings mentioned above. This meeting was usually attended by all teachers in this school and a few researchers from the Institute for Knowledge Innovation and Technology. Since this study was carried out as a part of a larger Social Sciences and Humanities Research Council (SSHRC) research project, I had already become familiar with these teachers through classroom observations one year before embarking on this dissertation study.

The choice of grades in School A for each study was intentional. When the study was first initiated, there was little knowledge about how capable elementary students were of making promisingness judgments. So I started from Grade 5/6—the oldest students in School A. After evidence of effective promisingness judgments under select conditions, the decision was made to explore Grade 3 possibilities; perhaps even younger students

---

could make effective promisingness judgments with proper supports.

In School B, Jane taught two classes of biology in Grade 6 and 9. She had a undergraduate degree in biology and a Master’s degree in education, and collaborated with Finn. I first met Jane and Finn at the 2010 Knowledge Building Summer Institute in Toronto, where Jane presented her Master’s thesis research conducted with Finn. She had twelve years of experience in teaching biology and five years of experience exploring Knowledge Building and Knowledge Forum. She was the head teacher in biology in School B and had been mentoring new teachers to the school.

**Students**

The three iterations of this dissertation research involved three cohorts of students from School A and B:

- 44 Grade 5/6 students from School A, Study 1 (22 students randomly assigned to the two classes at the beginning of the year through a school administrative assignment system);
- 40 Grade 3 students from School A, Study 2 (22 students with equivalent academic and ethnic backgrounds in two different classes engaged in the research over two consecutive years); and
- 26 Grade 6 students from School B, Study 3.

More detailed information about participating students is presented in later chapters.

### 3.5 Methods, Data Sources, and Analytic Approach

**Methods**

This dissertation research adopted qualitative and quantitative methods, in line with the benefits of using mixed methods (R. B. Johnson & Onwuegbuzie, 2004) and a more
holistic understanding of the targeted research problem (Creswell & V. L. P. Clark, 2007). The practice of applying mixed methods is also a general approach for design-based research (T. Anderson & Shattuck, 2012; The Design-Based Research Collective, 2003) in complex contexts requiring inspection from multiple angles, with qualitative and quantitative methods providing different perspectives into phenomena of interest.

In this dissertation research, my central concern was students’ socio-cultural interactions surrounding promisingness judgments. These interactions included identifying “promising ideas” written by individual students (selected from both own and peer notes contributed to Knowledge Forum), exchanges between students during and after the process of promisingness judgments, and collaborative efforts to improve identified promising ideas after selections were made. Other interesting phenomena included students’ perspectives of promisingness judgments, their epistemic cognition involved in the process of identifying promising ideas, and social cognition meditating the process. Although mixed methods applied in design-based research runs the risk of “over-methodologization” (Dede, 2004), different research findings uncovered through mixed methods help to elaborate research phenomena that would otherwise be neglected (Tashakkori & Teddlie, 2003). Therefore, multiple data analysis methods were applied to provide a detailed account of phenomena in this study.

Both confirmatory and exploratory data analysis techniques are incorporated (Onwuegbuzie & Teddlie, 2003). Because the practice of promisingness judgments was newly introduced to the classroom, exploratory measures were applied to describe its process and outcomes. Examples of these measures included descriptive statistics of students’ online activities in Knowledge Forum and knowledge building, ethnographic notes of classroom activities, and content analysis of student discourse. At the same time, confirmatory measures were also used to evaluate whether certain areas of development had been facilitated by classroom interventions, and to what extent. For example, analysis of variance (ANOVA) was used to assess knowledge advancement across different phases
of knowledge building. Correlation analysis was applied to inspect linkages between student promisingness judgments and other knowledge building behaviors. Some analysis results could serve as either exploratory or confirmatory measures. For example, while measures of Social Network Analysis were used to describe social interactions among students, comparisons of these measures across phases or among students could also serve confirmatory analysis purposes. Overall, various measures were combined to complement each other in order to study the research phenomena in a comprehensive manner.

**Data Sources**

Data for this study were drawn from several sources, including Knowledge Forum log data, video recordings of classroom discussion, artifacts produced by students in class, and field notes taken by researchers. In addition to these sources, the third phase of the study administered an online questionnaire to collect data about students’ domain knowledge and epistemic beliefs. Details regarding data sources will be presented in Chapters 4-6 corresponding to three design cycles.

**Analytic Approaches**

While three studies with somewhat different research questions and research settings were employed, the same basic analytic approach was applied in each. The primary analytic concern was effectiveness of students’ promisingness judgments as reflected in various aspects of knowledge building. Because different classes applied different approaches and had varied circumstances, it was necessary to first assess the actual enactment of classroom intervention by analyzing artifacts produced by students, field notes of researchers, and recordings of classroom discussions, focusing on the extent to which a classroom integrated promisingness-related thinking in knowledge building. Did the promisingness intervention go as planned? Was the intervention successful in helping students to grasp the concept of promisingness? These questions were addressed before actual assessment
of effectiveness of promisingness judgments interventions. Results corresponding to these questions are addressed in the first subsection of every Results section.

After assessing enactment of promisingness I analyzed the impact of promisingness judgments on various aspects of knowledge building discourse. These analyses were meant to address different socio-cognitive values of promisingness judgments. In particular, depth of idea development was assessed using content analysis (Chi, 1997) of student notes in different stages, focusing on scientific sophistication of ideas. To measure the breadth of idea development, semantic analysis were used. Social interactions surrounding promisingness judgments were assessed using social network analysis, focusing on changes of social structures in classrooms at different discourse phases. Additional cognitive dimensions, such as epistemic beliefs in science in the third research phase were measured using established instruments.

These different analyses are summarized in Table 3.3. Different analytic approaches were applied to different data sources in an effort to provide a comprehensive picture of classroom interventions so that this work may be reproduced and improved in other settings.

Table 3.3: Overview of Data Sources and Analytic Approaches

<table>
<thead>
<tr>
<th>Aspects</th>
<th>Questions</th>
<th>Data sources</th>
<th>Analyses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enactment</td>
<td>Classroom processes</td>
<td>Video recordings, field notes</td>
<td>Video analysis, descriptive analysis</td>
</tr>
<tr>
<td></td>
<td>Student conception of promisingness</td>
<td>Video recordings, artifacts, Knowledge Forum log files</td>
<td>Content analysis</td>
</tr>
<tr>
<td>Impact</td>
<td>Idea improvement</td>
<td>Knowledge Forum software notes, conceptual test</td>
<td>Content analysis, t-tests</td>
</tr>
<tr>
<td></td>
<td>Social dynamics</td>
<td>Knowledge Forum log files</td>
<td>Social Network Analysis, discourse analysis</td>
</tr>
<tr>
<td></td>
<td>Epistemic beliefs</td>
<td>Online questionnaire</td>
<td>Correlations, ANOVAs</td>
</tr>
</tbody>
</table>
Chapter 4

Study 1: Exploratory Research to Elicit Promisingness

4.1 Chapter Overview

The study reported in this chapter served as a starting point of the dissertation research, by examining students’ intuitive understanding of promisingness and their ability to make promisingness judgments (PJs) using a Promising Ideas (PI) tool. Two exploratory studies in School A were conducted; the specific research questions were:

1. How would young students with experience in knowledge building perceive the concept of promisingness, in advance of any efforts to facilitate their understanding?
2. To what extent would young students, in advance of efforts to facilitate understanding of promisingness, evaluate their ideas and those of their peers as promising—as having potential for further idea improvement?
3. What design interventions might improve students’ capacity to make promisingness judgments?

The first version of PI was used in two pilot initiatives—Pilot A and B—as described below. I highlight differences between pilot studies A and B, describe classroom imple-
mentations, present data analyses, and provide results of the two pilots studies. This chapter concludes with implications for follow up studies to be reported in Chapters 5 and 6.

4.2 Methods and Analyses

4.2.1 Participants

Participants in this study were students and teachers from two Grade 5/6 classes at School A. Each class included one teacher and 22 students, with approximately equal numbers of boys and girls in each class. Pilot A was carried out in both classes, taught by Brian and Jessica respectively. Pilot B was conducted only in the class taught by Brian.

4.2.2 Materials

Promising Ideas Tool, Version 1

As described in the Methods chapter, to support students making PJs in their knowledge-building discourse, a Promising Ideas (PI) tool was developed and continuously revised throughout this dissertation research. As the starting point of this dissertation, the pilot studies reported in this chapter used the very first version of PI, with the following two components.

1. Highlighting. A primary goal of PI is to provide an easy way to identify and aggregate promising ideas to better realize their knowledge building potential. Currently, students using Knowledge Forum typically use epistemic markers corresponding to theory development. These markers are embedded in a customizable scaffold tool that could be used to support promisingness, by tagging an idea with a promisingness scaffold (e.g., “A promising idea is...”); students could then view tagged ideas in their community
through a search facility. Alternatively students could use a reference facility in Knowledge Forum to collect promising ideas in a designated “promising ideas” note. So why a new promisingness tool? I believe a facility that gives prominence to promisingness—making it explicit in interface design with integrated functionality—will greatly increase the chances that promisingness will become integrated into student work.

The PI user interface for highlighting ideas is shown in Figure 4.1 and Figure 4.2. When reading a note, a student could highlight a text snippet by clicking on the “Ideas” button in the note reading interface (see Figure 4.1.a). After clicking, the default highlighting color—yellow—will be picked and the user’s mouse cursor will turn into a yellow light bulb. After a student selects an idea with the activated cursor, this idea becomes highlighted in the text-editing area and will be displayed in the idea box below (see Figure 4.2.a).

In addition, the highlighting function also provides a customizable color scheme to enable choice of ideas with different merits. To activate the scheme, a student can right-click (or control + click for Macintosh) on the “Ideas” button. A pop-up menu will appear (see Figure 4.1.b), and the student can then choose a color corresponding to a specific category he or she wishes to tag the idea with. This categorization color scheme could be customized by community members. For example, Green might be defined as “promising question” and Blue as “useful fact.” After the idea is identified with the “color wand,” its text is highlighted with that color in the note content editor pane and also shown in the idea text pane below (see Figure 4.2.b).

Furthermore, to avoid interference with individual reading, by default the tool will

---

1I wondered why ideas, especially good ones, were represented as light bulbs. A popular theory, which I think is highly plausible, is this symbolic link between ideas and light bulbs should be attributed to Thomas Edison—the America’s inventor—and his invention of the light bulb. First of all, there was no such thing as a light bulb before him because he invented it. Besides the light bulb, he invented and patented dozens of other applications and the Edison Labs were the very synonym of bright ideas for the first few decades of the twentieth century. Because Edison was the most celebrated inventor in his era and probably in human history, and because the lighting up of a bulb is metaphorically connected to the so-called Eureka moments, using a bulb to symbolize idea and invention becomes natural and intuitively straightforward.
(a) “Ideas” button in the note interface.

(b) Pop-up menu.

Figure 4.1: Highlighting functionalities of the Promising Ideas tool, version 1. In the note reading interface, users can click on the Ideas button to activate the highlighting facility. With one left-click, the default highlighting color (yellow) will be selected. To choose a different color or to access more advanced options users can right-click on the Ideas button for the pop-up menu.

only display ideas highlighted by the current user and hide those highlighted by others. If a user wishes otherwise, the “Show All Ideas” checkbox will enable her to review all ideas picked by her community in the current note. Moreover, the “Hide Colors” option enables a student to hide or show colors (including colors of ideas highlighted by her) in the note editing area (see Figure 4.1.b).

2. Idea aggregation window. While the highlighting component makes it possible to identify promising ideas, the idea aggregation function makes it possible to list all identified ideas from a Knowledge Forum view to facilitate further group deliberation (see Figure 4.3). In PI, this function is accessible from an idea button on the left pane of the view interface. This design was motivated by the knowledge building principle of community knowledge, collective responsibility, dedicating a space for the community to collectively decide for themselves on their next steps.

In addition to idea aggregation, an algorithm was implemented to merge overlapping
Figure 4.2: Highlighting ideas with PI, version 1. After the highlighting facility is activated, the mouse cursor will turn into a light bulb with corresponding color. After a student selects an idea with the activated cursor, this idea becomes highlighted in the text-editing area and will be displayed in the idea box below.
ideas and sort ideas according to the number of “hits.” ² When students collaboratively identify promising ideas in a Knowledge Forum database, their highlighted ideas are likely to overlap with each other. The algorithm made it possible to merge overlapping ideas into the largest text chunk in the overlapping set, and the number of hits was determined by the number of highlights in the merged set. After merging, all ideas are displayed in descending order according to number of hits (see Figure 4.3).

Finally, to view a selected idea in its original context, students can easily click on a hyperlink to open the note from which that idea has been picked. Overall, this idea aggregation component provides a means for a class or knowledge building community to review identified ideas and collectively make decisions for their work.

It should be noted that at the time the PI version 1 was designed, thoughts were mainly given to support PJs by students in knowledge-building discourse, without substantive consideration of facilitating further actions towards deepening knowledge building. At this point, PI is a “wisdom-of-the-crowd” facility that invites users to pick ideas they believe have greater potential in their community. Indeed, at this point the tool could be used to support anything from traditional peer assessment (how many highlights/hits each student receives), to idea picking/bookmarking by individuals, to knowledge-building “rising-above” or “best theory” purposes. To direct designs more toward idea improvability it became important to explore different socio-cognitive configurations to situate the use of this tool in a knowledge building context.

**Knowledge Forum Databases**

In both pilots, students made use of PI to evaluate ideas contributed to Knowledge Forum. In Pilot A, two Grade 5/6 classes reviewed notes produced by younger peers. In Pilot B the participating Grade 5/6 class reviewed their own notes. In Pilot A the Knowledge Forum database had one view containing 207 notes produced by a class of

² The implemented algorithm would merge $A$ and $B$ into $A$, if $A$ contains $B$. If $B$ has characters not within $A$, even if they overlap they will not be merged.
Figure 4.3: Idea aggregation window in PI, version 1. It aggregates all highlighted ideas in a view. This figure shows the top five ideas with the most hits.
Grade 4 students who were studying a science unit about rocks. The Grade 4 students were working on this view, entitled “Grade Four Rocks and Minerals,” the same year the pilot was conducted. Pilot B used was conducted on entries for another science unit, Electricity, generated by the participating Grade 5/6 students themselves over one semester. The view they reviewed was titled “Grade 5/6 Electricity” and contained 272 notes.

4.2.3 Design and Procedures

The two pilots followed similar procedures, each involving a one-hour session with the following three components:

1. *Introducing PI to students and teachers.* At the beginning of each session, PI was introduced to the class by researchers (two in Pilot A and one in Pilot B) through a short tool demonstration—an overview of features described in the previous section. Students and teachers were invited to pose questions which were addressed immediately.

2. *Promisingness judgments with PI.* Next students read notes in the Knowledge Forum database and identified promising ideas using PI. In each session, students worked either in pairs or individually, while researchers and teachers walked around the classroom to provide technical assistance, as needed.

3. *Reflection and discussion.* The class gathered to review the “idea list” containing ideas identified by students. During this process, students and teachers shared their general thoughts about the activity of identifying promising ideas, focusing on possible benefits for knowledge building. They also provided researchers with suggestions to help improve PI.

While both pilots followed similar procedures, there were significant differences reflecting the goals of exploring different pedagogical possibilities. In particular, Pilot
A provided minimal guidance to students regarding promisingness in contrast to Pilot B, which happened afterwards, explored a more meaningful scenario conducive to PJs. Reflecting these two different instruction configurations, Pilot A and B were designed differently mainly in three aspects: (a) instructions students received before using PI to highlight promising ideas, (b) students in Pilot A worked in pairs, whereas those in Pilot B worked individually, and (c) how PI was specially set up for students. Differences in these three aspects are summarized in Table 4.1.

Table 4.1: Comparisons of Design in Pilot A and B

<table>
<thead>
<tr>
<th>Pilots</th>
<th>Classes</th>
<th>Instruction</th>
<th>Grouping</th>
<th>PI customization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot A</td>
<td>Both classes</td>
<td>Check this Grade 4 class database about “Rocks and Minerals.” Use this PI tool to find the most “big” and promising ideas in the database. Think carefully about which types of ideas you will treat as promising.</td>
<td>In pairs</td>
<td>No customization</td>
</tr>
<tr>
<td>Pilot B</td>
<td>One class</td>
<td>You have been working on electricity for such a long time. You have gone through so much in learning this unit. It will be really helpful if we can reflect on the process of learning and help the class coming in next year to learn this unit better. Use the tool to tag different types of ideas in the database.</td>
<td>Individually</td>
<td>The color scheme in the tool was customized to meaningful idea types, including <strong>promising idea</strong>, <strong>unsolved problems</strong>, <strong>useful fact</strong>, and <strong>dead-end</strong></td>
</tr>
</tbody>
</table>

As shown in the table, in Pilot A students were instructed “to find the most promising ideas,” in a Grade 4 database; they were provided no guidance regarding the concept of promisingness and no PI color scheme. In contrast, Pilot B students were instructed to select ideas “to set up a workspace for the next class;” to further scaffold students’ PJs in this pilot, the color scheme was customized to represent four different types of ideas: **Most Promising Ideas**, **Unsolved Problems**, **Accepted Facts**, and **Dead-ends** (see Figure 4.4).
Chapter 4. Study 1

Figure 4.4: Customized color scheme in PI for Pilot B. The color scheme was customized to represent four different types of ideas: *Most Promising Ideas*, *Unsolved Problems*, *Accepted Facts*, and *Dead-ends*.

Having students use this scheme represented an attempt to support higher-order thinking activity (Bonk & Reynolds, 1997), and in turn, possibly set a more favorable stage for PJs.

In addition, in Pilot B I was interested in the linkage between one’s domain knowledge and one’s capability of making promisingness judgments. Toward this end, a paper-and-pencil conceptual test was administrated in Pilot B after the promisingness session to provide a measure of students’ domain knowledge. This test, see Appendix A, was composed of twelve grade-appropriate questions about electricity, including nine multiple choice questions and three explanation questions.

Moreover, I followed the whole semester of student work in Pilot B, so I had a good understanding of their discourse and ideas in this unit.
4.2.4 Data Sources

Knowledge Forum log data provided a major source of data in this design cycle. In Pilot A, two classes of students identified a total of 83 “promising ideas” from 207 notes. Among those ideas, 21 ideas were highlighted at least twice, and overall 45 distinctive ideas. In Pilot B, one class of students highlighted 90 ideas from 272 notes; after merging overlapping ideas, 71 of those them were found to be unique.

Video recordings of classroom discussion represented another important source of data in this study. Videos from both pilots were transcribed and used to inform interpretation of Knowledge Forum activities.

In Pilot B, student responses to a conceptual test about electricity were also analyzed (see Appendix A).

4.2.5 Data Analyses

Students’ PJs were examined under the two different experimental conditions. Content analysis (Chi, 1997) was conducted focusing on different aspects including the epistemic nature and structural complexity of identified ideas and agreement between students’ judgments and those of someone with more subject-matter knowledge. An overview of analyses is presented in Table 4.2, including research questions and reliability measure applied in each analysis.

Nature of Identified Ideas

To determine if promising ideas selected by students represented a good understanding of promisingness, I analyzed the epistemic nature of students’ selections of promising ideas. This analysis was designed to demonstrate if students selected ideas with potential for growth rather than important-sounding facts. In particular, a “ways of contributing to explanation-seeking discourse” scheme developed by Chuy and colleagues (2011) was applied to analyze the contribution types of identified promising ideas. This scheme was
Table 4.2: An Overview of Analyses, Questions, and Reliability Measures

<table>
<thead>
<tr>
<th>Pilots</th>
<th>Questions</th>
<th>Analysis</th>
<th>Reliability measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot A and B</td>
<td>To what extent could students identify ideas with a growth trajectory?</td>
<td>Nature of identified ideas</td>
<td>Independent second rater</td>
</tr>
<tr>
<td></td>
<td>Whether structural complexity of an idea had an impact on whether it will be identified?</td>
<td>Structural complexity</td>
<td>Independent second rater</td>
</tr>
<tr>
<td>Pilot A</td>
<td>Whether students were able to put ideas into corresponding information type?</td>
<td>Agreement with judgments by someone with more subject-matter knowledge</td>
<td>Time-delayed second rating by the same coder</td>
</tr>
<tr>
<td>Pilot B</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

developed based on a grounded theory approach (Glaser & Strauss, 1967) and applied to years of Knowledge Forum data with the goal of providing an inventory of students’ types of contribution to discourse. The analytic scheme includes 6 major categories and 24 sub-categories as shown Table 4.3.

In this study I focused on the major contribution types: formulating thought-provoking questions, theorizing, obtaining information, working with information, synthesizing and making analogies, and supporting discussion. The assumption underlying this analysis was that more promising ideas—those with greater potential for further improvement—would be of an explanation or theorizing nature; in contrast, ideas with lower potential for improvement would be more factual in nature. Accordingly, the distribution of contribution types in selected ideas would reflect whether students were holding a potential- or a fact-oriented conception of promisingness.

To establish reliability, two independent raters conducted the analysis. The inter-rater reliability as measured by joint probability of agreement was .75. Discrepancies were discussed to reach a final agreement.
Table 4.3: Ways of Contributing to Knowledge-Building Discourse

<table>
<thead>
<tr>
<th>Major categories</th>
<th>Sub-categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Questioning</td>
<td>1. Formulating an explanatory question</td>
</tr>
<tr>
<td></td>
<td>2. Asking a design question</td>
</tr>
<tr>
<td></td>
<td>3. Asking a factual question</td>
</tr>
<tr>
<td>II. Theorizing</td>
<td>4. Proposing an explanation</td>
</tr>
<tr>
<td></td>
<td>5. Supporting an explanation</td>
</tr>
<tr>
<td></td>
<td>6. Improving an explanation</td>
</tr>
<tr>
<td></td>
<td>7. Seeking an alternative explanation</td>
</tr>
<tr>
<td>III. Obtaining information</td>
<td>8. Asking for evidence</td>
</tr>
<tr>
<td></td>
<td>9. Designing experiment to test hypothesis</td>
</tr>
<tr>
<td></td>
<td>10. Reporting experiment results</td>
</tr>
<tr>
<td></td>
<td>11. Introducing facts from authoritative sources</td>
</tr>
<tr>
<td></td>
<td>12. Introducing facts from experience</td>
</tr>
<tr>
<td></td>
<td>13. Identifying design problems</td>
</tr>
<tr>
<td></td>
<td>14. Improving design problems</td>
</tr>
<tr>
<td>IV. Working with information</td>
<td>15. Providing reference or evidence to support a theory</td>
</tr>
<tr>
<td></td>
<td>16. Providing reference or evidence to discard a theory</td>
</tr>
<tr>
<td></td>
<td>17. Weighing explanations</td>
</tr>
<tr>
<td></td>
<td>18. Accounting for conflicting explanations</td>
</tr>
<tr>
<td>V. Syntheses and Analogies</td>
<td>19. Synthesizing available ideas</td>
</tr>
<tr>
<td></td>
<td>20. Creating analogies</td>
</tr>
<tr>
<td></td>
<td>21. Initiating a rise-above</td>
</tr>
<tr>
<td>VI. Supporting Discussion</td>
<td>22. Using diagrams to communicate ideas</td>
</tr>
<tr>
<td></td>
<td>23. Giving an opinion</td>
</tr>
<tr>
<td></td>
<td>24. Acting as a mediator</td>
</tr>
</tbody>
</table>

*Note.* Adapted from Chuy et al. (2011).
Table 4.4: Structure of the Observed Learning Outcome (SOLO) Taxonomy

<table>
<thead>
<tr>
<th>Levels</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pre-structural</td>
<td>Bits of disconnected information</td>
</tr>
<tr>
<td>2. Uni-structural</td>
<td>Simple and obvious, but unelaborated connections</td>
</tr>
<tr>
<td>3. Multi-structural</td>
<td>Connections between ideas, but no meta-connections or elaborated significance</td>
</tr>
<tr>
<td>4. Relational</td>
<td>Information meaningfully related to the whole</td>
</tr>
<tr>
<td>5. Extended abstract</td>
<td>Connections not only within the given subject area, but also beyond it; generalize and transfer principles</td>
</tr>
</tbody>
</table>

*Note. Adapted from Biggs and Collis (1982).*

**Structural Complexity**

Because greater structural complexity of ideas is typically valued in school learning, students might think that promising ideas were of higher structural complexity. To check this possibility, I used Biggs and Collis’ (1979; 1982) *structure of the observed learning outcome* (SOLO) taxonomy to evaluate the complexity of student selections in Pilot A. The SOLO taxonomy contains five levels of complexity as presented in Table 4.4. To establish reliability, another independent rater conducted the analysis. The inter-rater reliability as measured by joint probability of agreement was .7. Discrepancies were discussed to reach a final agreement.

**Agreement with “Expert” Rating**

In Pilot B, the PI tool’s color scheme was customized to include four judgments regarding information type: *most promising idea, unsolved problems, useful fact,* and *dead-end.* Data analysis was aimed at determining the extent to which student judgments were in accordance with those of someone with more subject-matter knowledge. To achieve this goal, one content “expert” (a graduate student with four years of post-secondary training in physics) coded the ideas using the same four-judgment scheme used by students. To establish reliability, time-delayed second rating was conducted. The agreement between two times of rating measured by Cohen’s Kappa was .86. Discrepancies were resolved
after further discussion between the “expert” and me. Student and “expert” judgments were correlated to determine agreement in making PJs in Pilot B.

**Conceptual Understanding in Subject Matter**

In Pilot B, a conceptual test was used to assess students’ understanding in electricity. Each student’s performance was scored according to the answer keys. Scoring was completed by a research assistant.

**Social Network Analysis**

In addition, because Pilot B engaged students in evaluating their own ideas, Social Network Analysis (SNA; J. Scott, 1988; Wolfe, 1997) was applied to investigate the extent to which students highlighted their own ideas as being promising. The contingency table between each pair of students defined by idea highlighting actions was inspected, so was the social network’s density, transactivity, and structure.

### 4.3 Pilot A: To Find the Most Promising Ideas

#### 4.3.1 Classroom and Knowledge Forum Activities

Note that each pilot was composed of three components—researchers introducing PI to students and teachers, students making promisingness judgments using PI, and whole class reflection and discussion regarding the experience of making PJ. This section describes classroom and Knowledge Forum activities occurring during Pilot A and presents descriptive analysis of them.

**Tool Demonstration**

During the tool demonstration in Pilot A, students grasped the functions of PI quickly. In most cases, students immediately understood the explanation of a specific function
and started to pose in-depth questions that anticipated the researcher’s explanation of
functions. For example, after the researcher demonstrated the process of highlighting
an idea, a student immediately asked what the four colors in the pop-up menu stood
for; after the researcher explained the idea aggregation window, a student noticed the
number beside each idea and questioned the meaning of it. Hence, students demonstrated
understanding of Knowledge Forum and PI. Since the Knowledge Building pedagogy and
technology had been introduced to them as early as Grade 1, understanding the functions
of PI did not appear to be a challenge for them. However, knowing how to use PI does
not, of course, imply making promisingness judgments that will advance community
knowledge. In-depth analysis, as presented below, was conducted on ideas highlighted
by students to provide indication of their understanding of the concept of promisingness.

Identifying Promising Ideas

Although students grasped the tool quickly in the first demonstration session, a few
students needed support during the second session which required using the tool to
identify promising ideas. Because students worked in pairs in this pilot, some issues were
resolved within pairs. In other cases, questions were quickly addressed by the teacher
and two researchers present in the classroom.

To identify promising ideas in the second session students read through the 207 notes
in the “Grade Four Rocks and Minerals” view produced by a Grade 4 class (see Figure 4.5)
who were working in the same school, same year. The Grade 5/6 students identified 83
promising ideas in total, with each student averaging 3.3 highlights. As indicated by
Figure 4.6, the majority of students highlighted 1 to 5 ideas, with only two of them high-
lighting more than 10 ideas. As discussed in Chapter 2, PJs may rely on expert intuition,
for those less experienced identifying promising ideas may require more time-consuming
reasoning processes. Accordingly to this analysis, students highlighting more ideas may
be spending less time reflecting on the selection. Thus, the two students highlighting
more than 10 ideas caught my attention. Further analysis of their highlights revealed a low level of engagement with the concept of promisingness in the sense of potential to advance community knowledge. For example, from one note—“Good question. I think rocks are formed by lots of minerals pushed together. And lots of dirt, and [for] thousands of years.”—one student highlighted two ideas as promising: (1) “rocks are formed by lots of minerals pushed together”, and (2) “lots of dirt, and [for] thousands of years”. The other student were seemingly interested in facts and highlighted several ideas such as: (1) “crystals that where 6 miles long”, (2) “like the grand canyon could have 912,456 layers of rock”, and (3) “Only 20% of Diamonds are gem quality and used for jewelry.” This finding suggests a bias toward fact-based selections. In any event, results suggested the need to clarify the concept of promisingness as ideas with potential for further knowledge building rather than those with factual bases.

Among the list of highlighted ideas, 21 of them were highlighted at least twice by dif-
Figure 4.6: The distribution of numbers of ideas highlighted by students in Pilot A. Two students highlighted 10 or more ideas as promising, while the rest highlighted 1 to 5 ideas.

Different students. Overlapping ideas were merged, resulting in 45 distinctive ideas present in the idea aggregation window in PI. Figure 4.3 presents the top five ideas, listing ideas with the most “hits” on the top. The hits of identified ideas ranged from 1 to 6, $M = 1.91$, $SD = 1.33$. As illustrated in Figure 4.7, most ideas received no more than two hits, with the distribution of hits flattening out beyond that point. As a “wisdom-of-crowd” tool, PI facilitated convergence of interests to a certain degree; however, such convergence appeared to be limited because a majority of ideas were highlighted by no more than two students. This finding could be explained by the limited amount of time available for students to go through a large number of notes; more specifically, in only 30 minutes of promisingness judgments, different students chose to read different ideas and made it difficult to converge on a same set of ideas. Additionally, because the Grade 5/6 students were reading notes produced by another class (i.e., Grade 4), they may not be very familiar with the content, although they would have studied a similar unit when they were in Grade 4. And of course judgment of idea promisingness is likely affected by
curiosity regarding new information (Litman, 2005); given diverse student backgrounds, selections might well diverge more than converge.

It should be noted, however, that the intention of promisingness judgments is not simply to converge on a short list of ideas, but to identify the most promising ideas for a community. The finding that students showed varied “tastes” in promising ideas indicated that this goal might be difficult to achieve. Also, what is promising in the idea may not be easily discerned from the text that is actually highlighted.

At the same time, the activity of identifying promising ideas did arrive at eight ideas highlighted by three or more students as being promising. Should they be treated as the most promising ideas in the community? What will happen to ideas not among the top? These questions called for additional socio-cultural configurations to guide PJs in fruitful directions.
Group Reflection and Discussion

The final reflection section of this session featured student reflection upon tool usage and their judgments of promisingness. First of all, students showed diverse understanding of the “usefulness” of identifying promising ideas in their discourse. For example, when one teacher asked how this tool could be useful, a few students responded:

S1: When you need to deal with a lot of notes, you can just quickly look at the highlighted sentences and you can get a lot of information.

S2: So if it’s a long note, it’s hard to really get the point I guess... You can highlight the information so it stands out to make it more easily accessed.

These statements of PJ’s usefulness centered on “information filtering” or reducing the problem space. While promisingness surely requires focus on key ideas, it also requires working through complexity to achieve explanatory coherence. Thus these responses do not reflect a very sophisticated account of promisingness. Some students went a bit further to stress the “interestingness” of ideas and actions. For instance,

S3: It’s easy to find all the information without going through everything so you can see what other people are interested in. So you can build on them here.

S4: Knowledge building is very complicated. I found another thing was I usually like it better when we have the big ideas because we have to search for these good information. We need to go through a lot of notes that are not really useful information. And there are actually quite a lot of those. So it does get a little tedious to go through all of them. I usually like to do something I’m interested in. With PI, I will find ideas I’m interested in more easily.

These two statements still emphasizing information filtering, but highlighted the purpose of information filtering was to “build on” or “do something I’m interested in” with identified ideas. However, equating promising ideas with ideas of interest to one’s classmates does not extend the idea of promising for knowledge building far beyond earlier ones.

More importantly, in these statements students did not explicitly address the “usefulness” of PJs to advance their knowledge. This gap was evident among almost all students
in this pilot, indicating the need for greater conceptual clarity regarding the concept of promisingness and PJs.

Interestingly, one student was not so concerned with reading less—just the “important” ideas, but rather an effort to bring some ideas to focal attention.

S5: When you are going through, that’s the point, you get to read the note. If it’s something you don’t hear about, something that you are not looking for in the database, then you can just let it go and go to another note that has something you are looking for. If it’s something you’re looking for, then you can highlight it, so other people can learn from that. So I think it’s good that you still have to go through.

Rather than focusing on information filtering, this student emphasized the importance of going through notes and “promising ideas” as “something you are looking for” and worth more attention.

During the reflection session, the teacher from one class asked her students whether highlighting promising ideas might help them write higher quality notes. Among responses from students, some focused on the “usefulness” of ideas in extending from their thoughts. Also, knowing their ideas would be evaluated in terms of promisingness, they realized they ought to think twice when making trivial and irrelevant contributions in Knowledge Forum. The quotes of two students provide rough indication of these PI benefits:

S5: It will help you a lot when you are doing research project. Because you don’t need to read all the notes... And also, if you read notes that are like add-ons, that say: ‘I don’t know let me research it.’ It’s kind of... You can say that to the person. So it’s good to have the main information here, but it would be good to somehow have it right there and we don’t need to search for ideas.

S6: I think I will probably write better. Because I remember when I wrote my first note when I was in Grade 5. That was ‘I’m the first one to write a note in this database.’

A more sophisticated conception involved the idea of integrating highlighted ideas in one’s own writing. This understanding was connected to the notion of “do something interesting” with identified ideas described above.
S7: I also think it can help writing your notes. Because you can find out what ideas people have, what they are looking at, so you can learn from that and put that into your own note.

Going further than recognizing the impact on reading and writing of notes, one student proposed to have “big idea periods” for each unit and suggested a higher “plane” of idea development on top of the PI tool. This student said,

S8: We can have big ideas period. Let’s say, yesterday everybody was on KF, and we built on each other’s notes. And today we have the big ideas thing, and we could look at each other’s notes and highlight big ideas. I think you should be able to, when you go into the big ideas list, I think you should also be able to... Let’s say, this idea... You have people being able to write down your own theories underneath that. Instead of having to build on the actual note, they can build on the big ideas directly in the idea box.

In summary, from classroom and Knowledge Forum activities, I found student capable of using PI, but limited conception of the role of PJs for knowledge building. Substantial individual variation was found, both in terms of highlight attempts and conception of PJs. Some students made more frequent PJ attempts, with selections closer to the fact-based conception of promisingness. A clear message was students would need more support to make promisingness judgments that might support the community in more significant knowledge advancement.

4.3.2 The Epistemic Nature of Identified Promising Ideas

An assumption underlying the data analysis is that students’ understanding of promisingness as potential for knowledge growth will be reflected in highlights that are “theoretical” or “explanation-seeking” in nature, as opposed to fact-based (important-sounding facts that are often the focus of what they are expected to learn). According to this assumption, analyzing the epistemic nature of ideas students highlighted would provide indirect evidence of the quality of student promisingness judgments. Content analysis of the epistemic nature of ideas was thus conducted.
Results of analysis are presented in Figure 4.8. According to this figure, 45.8% of the promising ideas identified by students were coded as theorizing contributions, suggesting an understanding of promisingness along a trajectory of improvement. Another 9.6% of highlighted ideas were “supporting discussion” contributions, found mostly in the “giving an opinion” sub-category. In addition, 8.4% of ideas were coded as questioning. The rest of identified contributions were “factual,” with 33.7% coded as obtaining information and 2.4% as working with information.

![Figure 4.8: The epistemic nature of highlighted promising ideas in Pilot A.](image)

As mentioned above, theorizing was considered in line with promisingness in the sense of “potential for knowledge building,” as it links promisingness and continual idea improvement. Table 4.5 presents a few examples of such ideas. As indicated by these examples, theorizing ideas highlighted during this pilot were not necessarily scientifically correct; rather, some of them carried misconceptions such as “giant rains forming the oceans” and “atoms becoming solid to form solid things.” However, these highlighted ideas seemingly reflected promisingness in the sense of explaining scientific phenomena and the ideas selected could obviously be put on a more scientific trajectory. Therefore,
when highlighting such theorizing ideas, responses were considered as indication of having “knowledge building potential.”

Table 4.5: Examples of Identified Ideas Coded Under the *Theorizing* Category

<table>
<thead>
<tr>
<th>Hits</th>
<th>Idea</th>
<th>Note title</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>[Y]ou know when the earth was just being created? There were volcanoes simultaneously erupting, creating tons of lava. but when the giant rains came (creating the oceans), the top of the lava flood cooled trapping the magma inside.</td>
<td>Creating the Crust</td>
</tr>
<tr>
<td>4</td>
<td>I do not think that chickens evolved from dinosaurs because if you get to separat[e] books one with a chicken one with a dinosaur they look nothing alike.</td>
<td>chicken and dinosaurs</td>
</tr>
<tr>
<td>2</td>
<td>[T]housands and millions years then the minerals and the atoms become solid and form solid things like rock</td>
<td>minerals and atoms</td>
</tr>
</tbody>
</table>

Highlighting questions as being promising was more complicated, in that questioning could be fact- or explanation-oriented and thus carry different levels of knowledge building potential. Previous research has distinguished different types or levels of questions, putting questions into *categories of or a continuum between* text- and knowledge-based types (Cuccio-Schirripa & Steiner, 2000; Scardamalia & Bereiter, 1992). Earlier studies found questions, especially those with higher levels, played an important role in tasks involving learning from information text (A. King, 1992; Taboada & Guthrie, 2006). Other studies also found questions benefiting peer interactions and cooperative learning (A. King, 1990). More relevant to this study, research of knowledge building classrooms has recognized *questioning* as one frequent contribution type (Resendes & Chuy, 2010) having the power to drive discourse to deeper levels (Hakkarainen & Sintonen, 2002). Therefore, in certain circumstances, questions can be conceptualized as promising in the sense of knowledge building potential.

Table 4.6 shows a few examples of highlighted questions. As indicated by these examples, questions such as “what is a rock” required factual answers that could be easily obtained from reference sources, and were accordingly considered low with respect to
knowledge building potential. In contrast, “how does coal become black” was considered to have greater potential because it required cause-effect explanations of science phenomena (Cuccio-Schirripa & Steiner, 2000). Further discourse analysis was conducted to understand the roles these questions played in specific discourse contexts. Results found these questions eliciting a variety of discourse moves such as proposing an explanation (e.g. “a rock is something that got hardened over time. It could be a sand stone, a lava rock and many different kinds of rocks.”), looking for evidence (e.g. “good question. I am not sure but the answer may be in a book in the classroom.”), and contradicting a theory (e.g. “I do not think that chickens evolved from dinosaurs because they look nothing alike.”). Therefore, although some of the identified questions would be considered to have low knowledge-building potential, those that elicited explanations of concepts and relations (A. King & Rosenshine, 1993) and required integration of complex information from multiple sources (Scardamalia & Bereiter, 1992) would be rated higher.

The high percentage of “facts/evidence” ideas highlighted by students was surprising. Although facts are important for explanation-seeking inquiry, fact-oriented discourse is thought to be not intentionally focused on advancing understanding and is thus “shallow” (Hakkarainen, 2003a; Lipponen, 2000). Therefore, students’ actions of highlighting important-sounding facts as promising ideas was considered a less sophisticated conception of promisingness. Indeed, student choices seemed to reflect what they believed to be important to their school work (see Table 4.7). Rather than highlighting something

Table 4.6: Examples of Identified Ideas Coded Under the Questioning Category

<table>
<thead>
<tr>
<th>Hits</th>
<th>Idea</th>
<th>Note title</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>why rocks are coulored?</td>
<td>why are rocks so colourful</td>
</tr>
<tr>
<td>2</td>
<td>what is a rock</td>
<td>rock?</td>
</tr>
<tr>
<td>1</td>
<td>if chicken’s evolved from dinosaurs, do</td>
<td>chicken’s</td>
</tr>
<tr>
<td></td>
<td>dinosaurs taste like chicken????</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>What is fossil fuel</td>
<td>what is fossil fuel</td>
</tr>
<tr>
<td>1</td>
<td>How does coal become black?</td>
<td>black coal</td>
</tr>
</tbody>
</table>
Table 4.7: Examples of Identified Ideas Coded Under the *Facts/Evidence* Category

<table>
<thead>
<tr>
<th>Hits</th>
<th>Idea</th>
<th>Note title</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>explorers went in to a cave and found crystals that were 6 milers long.</td>
<td>crystals</td>
</tr>
<tr>
<td>3</td>
<td>Diamonds [are] evaluated based on the “Four Cs” of carat, clarity, Cut, and colour.</td>
<td>The four c</td>
</tr>
<tr>
<td>2</td>
<td>Rocks are made by minerals coming together over many millions of years.</td>
<td>minerals and rocks</td>
</tr>
<tr>
<td>1</td>
<td>the earth is 4,000,000,000 years old</td>
<td>13,000,000,000</td>
</tr>
</tbody>
</table>

Figure 4.9: An example of factual contributions highlighted as promising in Pilot A. This note contained nine facts about the earth, with page numbers in their source.

with a promising growth trajectory, facts got highlighted because of some distinctive “attractiveness”—possibly because learning such information is promising from the perspective of reading comprehension or doing well on tests or traditional classroom activities. There was a note containing nine facts about the earth, although lacking specific context (see Figure 4.9). Such a note could seem “promising” because of its detailed information, but it may not necessarily be promising for a knowledge-building dialogue.

A considerable portion of highlighted ideas being facts or evidence raises several issues: students may have a bias for promisingness in the sense of important for typical school work; the PI tool alone is clearly not sufficient for bringing ideas to focal attention that
helps drive community knowledge; and technological supports need to be embedded in more meaningful contexts.

4.3.3 Were Student Judgments of Promisingness Based on Structural Complexity of Ideas?

The results of analyzing the epistemic nature of ideas, especially students’ inclination to highlight important-sounding facts as promising ideas, implied the existence of other factors that had potentially affected students’ PJs. *Structural complexity* could be a factor. To explore whether an idea’s structural complexity would affect its chance of being identified as a promising idea, the *SOLO taxonomy* (Biggs, 1979, see Table 4.4) was applied to evaluate the structural complexity of highlighted “promising” ideas.

The structural complexity was separately inspected for different types of contributions. Results showed all identified facts and questions resided on the *pre-structural* and *uni-structural* levels, showing no or little intention to integrate information. One possible explanation would be that the Grade 4 students’ ideas that were evaluated by the 5/6th graders in this pilot were structurally simple by themselves; that is, the 4th graders were inclined to ask factual questions or introduce evidence with little obvious connection to the problem. As a result, the pool of selection for the 5/6 graders left them little chance to select complex questions or facts. Further analysis of other questions and facts supported this explanation, as other factual and questioning contributions in the Grade 4 database were not complex either. Therefore, it was difficult for this analysis to provide further insight into possible connections between structural complexity and selections of questions and facts.

As for the 53 theories identified as promising, the structural complexity was more diverse. Figure 4.10 presents the distribution of their complexity levels. As indicated by this figure, the majority of these theorizing contributions were *uni-structural* or *multi-structural*, and none of them reached the level of *extended abstract*. 
Figure 4.10: Distribution of structural complexity of theorizing contributions in Pilot A.

In order to examine whether students tended to highlight theories with higher structural complexity, a one-sample chi-square test was conducted. The results of the test were nonsignificant, $\chi^2(3, 53) = 3.23, p > .05$, which implied the distribution of SOLO levels was not significantly different from a chance distribution. Overall, structural complexity was not found to be a significant factor in students’ PJs. But again, this result might also be related to low idea complexity in the Grade 4 class’ knowledge building work.

4.3.4 Summary of Results

In Pilot A students were simply asked to find promising ideas from an existing Knowledge Forum database based on whatever promisingness criteria they had in mind. Results indicated that students learned the Promising Ideas tool quickly and to some extent grasped the usefulness of highlighting promising ideas. However, the analysis of the epistemic nature of the ideas they highlighted revealed a fact-based account of promisingness. That is, students were inclined to regard important-sounding facts as promising ideas even
though their judgments were not based on structural complexity of ideas. Moreover, analysis of student discussion also showed they had little awareness of the significance of making quality promisingness judgments, and some students demonstrated little engagement with the promisingness concept during their PJ attempts. These results made it apparent that a more meaningful context for work on promisingness, including discussion of different conceptions of promisingness and the notion of promising ideas to advance knowledge building discourse, were needed.

4.4 Pilot B: To Set Up a Workspace for the Next Year’s Class

4.4.1 Classroom and Knowledge Forum Activities

To explore possible supports for student promisingness judgments, in Pilot B I experimented a different approach. In particular, students reviewed a Knowledge Forum view about “Electricity” they had been working on for one semester (see Figure 4.11). Note that this view was a re-organization of the original view students worked on; the notes were regrouped by a researcher based on conceptual topics in order to facilitate students’ evaluation processes. As reflected in the Knowledge Forum view, students had been working on a number of different themes, ranging from more traditional elementary electricity topics such as battery, circuits, conductivity, magnets and static electricity, to more advanced ones such as electromagnetism and atoms.

To recap, this pilot followed similar procedures as Pilot A, including (a) one researcher introducing PI to students and teachers, (b) students making PJs using the PI tool, and (c) group reflection and discussion. Rather than using PI to work with ideas created by other students, they were working with a view they created, reading their own and classmates’ notes and selecting promising ideas as part of a reflective journey of their work
on electricity, with the goal of defining a new workspace for the next Grade 5/6 class. By situating student PJs in this new scenario, I was expecting to draw their judgments closer to selection of ideas that they judged to have potential for knowledge building.

**Articulating Highlighting Scheme**

In this pilot the teacher introduced the idea of setting up a workspace for students to use in a subsequent year.

Teacher: It has been one of the biggest [views] we’ve ever had. So for all this work, we get to think about what happens to all this work. And it’s actually quite messy. So I am going to just ask you to do one last thing on the Knowledge Forum today. We get to think, what would happen if another class starts to study electricity, or physics, or something like that, this may not make a whole ton of sense to them.

After prompting students to think about the idea of using what they have achieved to benefit the next class’ work, the teacher further articulated the purpose of this session, which was to help the next class identify problems worth solving, ideas worth further
investigation, and “hurdles” to be avoided. Then the teacher explained the color-coded highlights for customized PI: most promising ideas, unsolved problems, accepted facts, and dead-ends. These were thought to loosely represent four levels of promisingness. This design was inspired by results from Pilot A and used to determine if students could distinguish ideas along different lines.

Students were asked to think of examples and share them with the class, starting with “accepted facts.”

Teacher: Some of the notes up here are probably ideas that we now kinda accept as true, facts, ... things we found these are actually true. Can any of you tell me one thing that is in that category?
S1: Battery produces electricity.
S2: Individual atoms do not have color at all, but when you group them they might have color.

There were no objection from other students, and this class of students appeared to have a sense of accepted facts. After articulating “accepted facts,” the teacher moved onto discussing “dead-ends.” He recognized that referring to a student’s contribution as a dead-end could jeopardize one’s feeling of safety in future knowledge building, so handled this with great care. He said:

Okay, there might be some... this might be hard to say... I am not sure whether I can say... If there is something up here that you think is a fact, is there something that you read as a “dead-end?” This is an idea that you think will go somewhere, but in fact, it’s a bit of a dead-end. Or maybe it is not going to lead us to any direction we can go. What do you think?

Fortunately, students turned out to be comfortable talking about “dead-ends” in their work. As one student immediately responded:

S3: We had this idea that there is mini batteries inside a battery, and inside mini batteries there are mini-mini batteries. This idea didn’t go anywhere.
S4: I am thinking of light [which we didn’t get too far].

Based on my understanding gained from following their work, these two examples reflected areas they had made least progress in. By tracing notes written by these two
students, I found S4 was referring to her group’s notes about the relation between electricity and computer screens. For her, recognizing her own ideas as “dead-ends” did not appear to be discouraging. However, because only these two students got a chance to speak, I was not able to assess feelings of other students.

Discussion of the other two idea types was brief, if any at all, with the teacher only mentioning them.

T: There also could be something called “unsolved problems” or “promising ideas,” ideas that we didn’t get a chance to finish, or ideas that will still move us in a great direction if we have more time to deal with them...

T: Highlight the ideas that are either promising ideas that will take us somewhere or some other people may want to know about.

Interesting enough, at the end of the discussion, one student asked the question: “What if we put a same idea into two different categories?” The teacher did not provide any direct response. However, this question demonstrated deep engagement of this student with these idea types.

Tool Demonstration and Activity Instruction

After completing a discussion of the four types of selections students were to make, the teacher demonstrated the PI tool. Students understood the tool very quickly and posed a few clarification questions about the tool. After addressing these questions, the teacher provided the final instruction before students started using PI to highlight ideas.

Teacher: Choose one of the areas [or topics] and read all the notes, and highlight the ideas that are either promising ideas that will take us somewhere or some other people may want to know about, versus the “dead-ends”, versus the unsolved problems, or accepted facts. After that, we will put each of these groups [of ideas] into separated views, so the next group—maybe that’s like the 2014 class—could look at that, and they could build upon that.

Students: Wow, that’s so cool!

The students did show some excitement after knowing the work they were doing would impact the next class studying this unit. Although this pilot did not intend to
study the linkage between emotions and decision-making, being charged with positive emotions was likely to improve students’ judgment and decision-making (Bechara, 2000; Bolte et al., 2003; Simon, 1987). From this aspect, the socio-cognitive design in Pilot B was successful in situating students in a more favorable situation to make PJ.

Because there were too many notes for a student to read through in one class session—another lesson learned from Pilot A—after the teacher’s instruction each student was asked to choose one topic to focus on (see Figure 4.11 for available topics). Then each student worked independently to evaluate ideas.

Identifying Promising Ideas

During this section, students highlighted a total of 90 ideas. Hits for each idea ranged from 1 to 5, resulting in a total of 77 unique ideas. The top four ideas are presented in Figure 4.12. Examples of highlighted ideas can be found in Figure 4.13. As indicated in Figure 4.14, except for one student highlighting 16 ideas, the other students were distributed between 1 and 9.

Group Reflection

Because of the time limit, in Pilot B the class only spent approximately five minutes discussing the results of promisingness judgments. This discussion focused on “accepted facts” students identified, as the teacher was keen on whether the whole class as a community had a shared understanding of accepted truths at the end of the unit. During the discussion, the teacher read the top two highlighted “accepted facts” (see below) to the whole class and discussed them with students.

Accepted fact 1: It is impossible for an atom to not have electrons, neutrons or protons because atoms are neutrons has both protons and electrons

Accepted fact 2: In batteries there are protons, neutrons and electrons and the light bulbs already have the protons and neutrons in them and only need electrons to light up so only the electrons move from the battery to the light bulb.
Figure 4.12: Idea aggregation list produced by students in Pilot B. The top four ideas with the most hits are listed in this figure.
Figure 4.13: Notes with ideas of different types highlighted within. Note in Pilot B the color scheme was customized to represent four different types of ideas: Most Promising Ideas, Unsolved Problems, Accepted Facts, and Dead-ends.
Students did not show differentiated opinions on these two ideas. However, interestingly some students further problematized these two highlights with follow-up questions.

S: I have a question. If it [electron] goes back into it, why the battery seems to lose energy overtime?
T: Maybe it’s an unsolved problem for circuits.

Apparently, although the promisingness deliberation activity was carried on in the end of the unit, students were still actively debugging their ideas. At the same time, the teacher somehow responded to the earlier question one student asked—What if we put a same idea into two different categories?—noting an accepted fact at a time could become an unsolved problem. Unfortunately, Pilot B was conducted near the end of this unit and the class did not have a chance to further work on identified ideas. However, this observation highlighted that when students are engaged in decision-making for future actions, they could seem more engaged in making productive judgments, and more importantly, commit themselves to ideas worth exploring.

4.4.2 Ideas Identified by Students

In Pilot B, 19 students highlighted more than one idea. The whole class highlighted a total of 90 ideas. The number of ideas highlighted by each student ranged from 1 to 16, \(M = 4.74, SD = 3.8\), showing substantial individual variation.

Note that in Pilot B we set up the color scheme in the PI tool with four pre-defined selection types, as presented in Figure 4.15. Compared with Pilot A, and seemingly because of four-choice customized color scheme, students in Pilot B did not identify many “most promising ideas” from their work; as indicated in Figure 4.15, only 9 ideas got identified (out of 90 highlights). One could argue that this is how it should be, as promising ideas are usually scarce in knowledge work. In any event it seems students in Pilot B were making more discerning judgments regarding PJs. More detailed evaluation of student highlights was needed to confirm this conjecture, as indicated below.
In Pilot A students were simply instructed to identify promising ideas in contrast to Pilot B where they made choices between types of ideas to highlight. Without concrete options provided in Pilot B, students in Pilot A seemed less selective in their PJs. However, Pilot A and B differed in several ways, as was the intention in this early exploratory work. Hence, results are suggestive, at best.
4.4.3 The Epistemic Nature of Identified Promising Ideas

As described in the previous section, out of 90 highlights, only 9 were tagged as “most promising ideas.” As in Pilot A, I was interested in the epistemic nature of identified promising ideas and coded contribution types.

Content analysis of ideas highlighted by students showed all ideas as theorizing, except for one questioning contribution, suggesting that, compared to Pilot A, students in Pilot B were more selective in identifying promising ideas, focusing more on ideas with a developmental/theoretical trajectory than fact-based.

4.4.4 Did Student Assessments Correspond with the Judgment of Someone with More Subject-Matter Knowledge?

To assess the extent to which ideas students highlighted corresponded to that of someone with more knowledge of the field, one rater with post-secondary training in physics coded students’ highlighted ideas following a 5-point Likert scale: from 1—“the lowest match,” to 5—“a perfect match.” Results of descriptive analysis of student performance in each category are presented in Figure 4.16. Results indicated that students matched to “expert” judgments were closer with respect to “accepted facts” ($M = 4.52$, $SD = 0.73$) than “unsolved problems” ($M = 3.94$, $SD = 1.34$), “dead-ends” ($M = 3.26$, $SD = 1.46$), or “most promising ideas” ($M = 2.67$, $SD = 1.58$).

Further analysis of variance (ANOVA) of student performance confirmed a significance difference, $F(3, 86) = 6.48$, $p < .001$. Post-hoc analysis found students doing significantly better in correspondence with expert ratings with respect to accepted facts than with dead-ends (Cohen’s $d = 1.26$, $p < .01$) and promising ideas (Cohen’s $d = 1.85$, $p < .01$), and significantly better in correspondence regarding unsolved problems than promising ideas (Cohen’s $d = 1.27$, $p = 0.05$).

Compared to students in Pilot A, results suggest that students in Pilot B were more
attuned to selections following the growth trajectory conception of promisingness. However, evaluating promisingness of ideas still represented a challenging task. Grade 5/6 student agreement with “expert opinions” regarding accepted facts and unsolved problems was higher than with promising ideas. There was even a tendency to have better match with ideas not considered promising, i.e., dead-ends (a nonsignificant but interesting result). Of course, promisingness is in the eyes of the beholder, and there may be as low agreement between experts as between Grade 5/6 students and experts. Unfortunately the sample size is too small to pursue this possibility, but it represents an important matter for future research.

4.4.5 Were Students Inclined to Highlight Their Own Ideas?

In contrast to the situation in Pilot A, in Pilot B students evaluated promisingness of their own community ideas. Therefore, it was of interest whether students tended to highlight their own ideas over contributions of peers. A preliminary analysis of social networks based on idea highlighting was conducted. Figure 4.17 shows a contingency table of idea highlighting among students. In this figure, each student is represented in
both dimensions. The number in a cell denotes the count of promisingness highlights one student (in the vertical dimension) made on another student’s (in the horizontal dimension) contributions. As reflected in the results, out of 90 actions of idea highlighting, only 8 actions were about one student highlighting his/her own notes, which correspond to the diagonal line of the contingency table. These 8 highlights included the case of one highlighting one’s co-authored notes. Thus, when picking promising ideas students did not show preference for their own contributions.

Further analysis of the highlighting social network revealed a connected network. The social network is visualized in Figure 4.18. Although density of the social network was not high, .18, the network had a considerably high transitivity of .45. That means, among all possible triads, 45% of them were “transitive”—displaying a type of transitivity where, if A directs a tie to B, and B directs a tie to C, then A also directs a tie to C. In the context of this study, it implied a considerably balanced social network which contained less “isolation,” “couples only,” or “structural holes” (Borgatti, Mehra, Brass, & Labianca, 2009).

4.4.6 Relationship between Promisingness Judgment Performance and Content Knowledge

Descriptive analysis presented for Pilot A found great variance in terms of the number of highlighting attempts among students ($M = 4.74, SD = 3.8$). In Social Network Analysis presented in the previous section, disparity was again observed in the contingency table shown in Figure 4.17. By summing up each row, outdegree—which denotes the number of highlights one student made—could be calculated; similarly, indegree can be computed based on the sum of each column. While students were found making different numbers of PJ attempts (represented by outdegree), they also differed in receiving their peers’ highlights (indegree). For example, S3, S4, S6 and S20 were highlighted by their peers multiple times, whereas S1 was only highlighted once. Furthermore, some students, S19
Figure 4.17: Contingency table of idea highlighting behavior among students in Pilot B. Each student is represented in both dimensions: vertical and horizontal. The number in a cell denotes the count of promisingness highlights one student (in the vertical dimension) made on another student’s (in the horizontal dimension) contributions.
Figure 4.18: Visualization of social network based on idea highlighting in Pilot B. Each node denotes one student. Each arrow denotes the existence of directional idea highlighting between two students.
for instance, were found making a lot of PJ attempts, but not being highlighted by others.

In this pilot, students’ content knowledge was measured with a conceptual test after the promisingness session. To probe possible connections between content knowledge and the performance of making PJs, measured by the mean score of “expert” evaluation in Section 4.4.4, correlation analysis was conducted among four variables: (1) \textit{indegree}, (2) \textit{outdegree}, (3) \textit{agreement with expert judgments}, and (4) \textit{conceptual test scores}. Results are presented in Table 4.8.

Table 4.8: Correlations Between Promisingness Judgment and Content Knowledge

<table>
<thead>
<tr>
<th>Measures</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Indegree</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Outdegree</td>
<td>-.50*</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>3. Expert agreement</td>
<td>.52*</td>
<td>-.05</td>
<td>–</td>
</tr>
<tr>
<td>4. Conceptual test</td>
<td>-.08</td>
<td>.50*</td>
<td>.08</td>
</tr>
</tbody>
</table>

* $p < .05$.

Results indicated students’ PJ performance as measured by agreement with experts was not significantly correlated with content knowledge, $r = .08$, n.s., but with the count of one’s ideas being highlighted as promising by other students, $r = .52$, $p < .05$. This suggests one’s community “clout” could be a predictor of one’s PJ performance, rather than the level of content knowledge.

The number of highlights a student made was found negatively correlated with the number of highlights one received, $r = -.50$, $p < .05$. The negative correlation indicated a disparity in terms of conceptual influence in the community. Students who attempted to highlight more ideas ended up being highlighted less by others, whereas ideas contributed by students who highlighted less got more recognition. This disparity suggested a need to improve students’ understanding of promisingness.
4.5 Discussion

4.5.1 Major Research Findings in Two Pilots

From classroom discussion, we found Grade 5/6 students in this study acknowledged the complexity of knowledge building and recognized the usefulness of the PI tool for finding the most interesting ideas. They identified new possibilities for use of the tool, such as integrating ideas identified as promising into their own notes. Thus, these students could see how PI could advance their knowledge building efforts.

Since understanding the promisingness of ideas is a significant challenge in knowledge creation and an important component of knowledge-building discourse (Bereiter & Scardamalia, 1993), it was important to get a basic understanding on what conditions are conducive to promisingness judgments. Pilot A suggests that using PI without prior discussion of the concept promisingness led to selection of ideas that were interesting or useful in different ways, but not reflecting the notion of promisingness in the sense of ideas with potential to further advance understanding and create breakthroughs for the community. In particular, students were inclined to select important facts of the sort they address in their school work. In contrast, in Pilot B where they were engaged with their own ideas and arguably a more meaningful scenario for the use of PI, students made selections more in keeping with the concept of promisingness as advanced in this thesis. However, both pilot studies uncovered individual variation in terms of the capability in making PJ, suggesting the need for greater support for understanding the concept of promisingness.

4.5.2 Lessons Learned from the Exploratory Study

Lesson 1: The Effect of PI Alone Is Minimal

As the starting point of this dissertation, the exploratory study provided important insights regarding students' promisingness judgments. As suggested by the comparison
between Pilot A and B, the challenge is to create a meaningful context for the use of PI. This of course seems to go without saying; nevertheless the results point to specific forms of work with ideas that engage students in thinking of them on a growth trajectory. In particular, selecting ideas for different purposes seems to support them in making more discerning judgments.

**Lesson 2: Reflection on Promisingness Judgments Is Critical**

In both pilots, students demonstrated little awareness of the importance of the promisingness judgments that might be brought to the attention of the community and serve to support the community in greater knowledge advancement. While there was no indication of students taking a meta perspective on their promisingness judgments, it was interesting that one student raised the notion of “promising ideas period” so they could reflect on their ideas periodically. However, there was little suggestion of committed effort to become better at making promisingness judgments.

This shortcoming could be attributed to limitations of the research design. First, in both pilots promisingness judgments were conducted in a “one shot” session and there were no consequences related to the form their promisingness judgments took. In subsequent iterations of this research efforts were made to design interventions to engage students in progressive idea improvement surrounding promisingness judgments so students experience successes and failures of their judgments. In this way, students have a chance to reflect on and improve these judgments.

**Lesson 3: Let Student Promisingness Judgments Inspire Future Actions**

Interestingly, students recognized the usefulness of PI immediately and were aware that it could raise awareness of each other’s contributions and help them incorporate other ideas into their writing. It should also be noted that in Pilot B, during the reflection on “accepted facts” that had been identified as promising, students started to debug those
“facts” by problematizing explanations with new observations.

Although PI had the list function that aggregated highlighted ideas for further discussion, it fell short in encouraging further actions, such as building on, annotating, synthesizing, on identified promising ideas. This inspired me to redesign PI, to make results of promisingness judgments leading more readily to future actions. So I further reengineered this tool to better convey the essence of promisingness—“to guide future actions.”

4.6 Chapter Summary

This chapter has provided an account of Grade 5/6 students’ intuitive understanding of the concept of promisingness and their promisingness judgments in two different pedagogical configurations. Results revealed the significance of pedagogical supports for promisingness judgments. This finding inspired the second design cycle presented in the next chapter, which investigated knowledge processes of promisingness judgments with greater support for understanding the concept of promisingness and follow-through on judgments.
Chapter 5

Study 2: Promisingness Judgments with Principle-Based Pedagogical Supports

5.1 Chapter Overview

Following from lessons learned from Study 1 with Grade 5/6 students, in the second iteration of my design-based research I introduced advanced socio-cognitive supports for promisingness, together with a refined Promising Ideas (PI) tool. In Study 2 I pursued the possibility that even younger, Grade 3 students would benefit from support in making promisingness judgments (PJs). In this chapter, I begin with research questions followed by research methods, including a description of new PI socio-cognitive designs. Then I introduce data analysis approaches aligned with research questions, followed by presentation and discussion of results, and conclude with a section on lessons learned and possible areas of improvement to support PJs.

Research questions:

1. Do grade 3 students have any awareness of promisingness of their own ideas? What
is their intuitive understanding of promisingness?

2. Is it possible to raise students’ awareness of promisingness and correspondingly their ability to make promisingness judgments regarding their ideas and those of their peers with respect to potential for further idea improvement?

3. How might promisingness judgments influence knowledge-building discourse, at individual, group, and community levels?

4. Can promisingness judgments facilitate knowledge advancement in a knowledge building community?

5.2 Methods and Analyses

5.2.1 Participants

The design involved one experimental and one comparison class from two consecutive Grade 3 cohorts (2010 and 2011) at School A. The 2010 cohort \((n = 20, 10 \text{ boys and } 10 \text{ girls})\) was treated as a comparison group for the 2011 experimental class \((n = 20, 11 \text{ boys and } 9 \text{ girls})\). The two classes were taught by two different teachers—the comparison group by a teacher with more than three years of experience with Knowledge Building, while the teacher for the experimental class was at School A for a one year exchange program. As a result, although the two classes were led by two different teachers, to the extent that there may have been a “knowledge building” teacher advantage, the advantage would be in favor of the comparison group. Students in both classes, most of whom were at School A for the previous two years, had been taught by the same two teachers in their first and second grades. And the dynamics in the two classrooms were similar; not only were both teachers present in weekly Knowledge Building meetings but the teacher who taught the comparison class provided considerable advice to the other teacher. Thus there were close parallels in terms of class design, as will be elaborated below. The difference, as will also be elaborated below, was in implementation of pedagogical and technological
supports for promisingness.

5.2.2 Technological Supports for Promisingness

Promising Ideas Tool, Version 2

In Study 1, students made PJ selections and classroom discussion showed sporadic efforts to problematize and improve ideas that had been highlighted as promising. However in Study 1 there was no follow up activity that gave students opportunity to experience the consequences of PJs, and consequently no way to analyze the impact on ongoing knowledge building efforts.

To tackle issues in this design cycle, I redesigned PI, introducing a third component to the tool. Note that in Study 1, PI had two components: (1) *idea highlighting*—to select and “elevate” ideas from notes; and (2) *idea aggregation window*—to aggregate highlighted ideas in a list.

The third component introduced in the second design cycle was an *exporting* facility whereby identified promising ideas can be exported from the list to a new workspace for further inquiry. The design intention was to empower students to utilize PJs to make decisions on their ongoing knowledge building. With this function, students’ review of the idea aggregation list could be oriented towards decisions on which ideas they should focus on next. From the idea list, they can collectively select the most promising ideas and export them to a new Knowledge Forum view by clicking on the “Export Notes” button (see Figure 5.1). Students are then prompted to give a title to the new view, to which notes containing those selected ideas will be copied. After that, students can work to further improve them towards their knowledge goals in the new, conceptually higher-level space.

The new exporting function was an important addition to PI. From a theoretical point of view, PJs would be most meaningful in a knowledge creation context, in which the goal is to advance the frontier of community knowledge. Thus, what becomes important
Figure 5.1: Export selected ideas to a new view, with PI version 2. Users can select ideas from the aggregation list (in the background) and export them to a new view.
is not the promisingness judgment in its own right, but efforts to improve ideas based on selections—to move them to a new workspace. This export facility makes the endeavor of identifying promising ideas more meaningful by aligning it with real-world scenarios of choosing “pregnant ideas” to focus on in scientific investigations (Gardner, 1994). With this new addition, the tool encourages students to identify promising ideas with commitments to improve them.

**Knowledge Forum Databases**

In this study, Grade 3 students from both the 2010 and 2011 classes used Knowledge Forum. The 2010 Grade 3 class produced five Knowledge Forum views, including “Grade Three Soil,” “Worm Anatomy,” “Worm Life Cycle,” “Worm Behaviour,” and “Worm Habitat.” The 2011 Grade 3 class had three views, including “Grade 3 Soil,” “Where does soil come from,” and “Soil and Worms.” Over the course of one semester, two classes wrote equivalent numbers of notes in their respective databases. However, only students from 2011 used PI to evaluate promisingness of their ideas.

### 5.2.3 Pedagogical Supports for Promisingness

In Study 1 I found that without sufficient exploration of the promisingness concept, Grade 5/6 students tended to identify important-sounding facts as promising, rather than ideas with greater knowledge building potential. What seems required, in order for children to successfully assume agency in identifying and pursuing promising ideas, is enculturation into a promising-idea way of thinking about and using promising ideas—a way to deepen knowledge-building discourse. To establish this, in Study 2, I focused on the socio-cultural context for engagement with promising ideas, with attention to the following two components.
(a) Promisingness Concept Elicitation

To make meaningful PJs, the first challenge for students is to understand the concept of promisingness. To tackle this challenge, I worked with the teacher to design pedagogical supports to engage students in productive discussions of promisingness. Then under teacher guidance students’ prior conceptions of promisingness were elicited so that they could be brought to the whole class for discussion. This discussion served to advance different but plausible definitions of the concept and support them with meaningful examples. During this discussion, the teacher raised the issue of regarding facts as promising ideas, as identified in the first design cycle. Students were invited to ponder on differences between facts and ideas, to conceptually distinguish promisingness from “truthfulness.” By involving students in exploration of the concept, this pedagogical support sensitized them to the distinction between fact-based and knowledge-advancing conceptions of promisingness, with the expectation that they would then, in incremental and gradual manner, reflect on different possible conceptions of promisingness and apply them with increasing effectiveness given time and experience.

(b) Turning Over High Level Processes to Students

From Socratic instruction to project-based learning to inquiry learning, the right of deciding how classroom processes will unfold mostly belongs to the teacher or instructional designers, with students seldom given the opportunity to direct their learning path. The Knowledge Building approach attempts, in contrast, to establish a model of teaching that turns over high-level agency and cognitive responsibility to students—responsibility such as setting cognitive goals, asking questions, and monitoring and directing inquiry (Bereiter & Scardamalia, 1987; Scardamalia, 2002; Scardamalia & Bereiter, 1991). Supporting students to make promisingness judgments is essential to help them assume more agency in knowledge building. For this purpose, I designed socio-cognitive processes to engage students in evaluating the promisingness of ideas in their community. The goal of
the design is to make students’ decisions in promisingness judgments impactful for their knowledge-building discourse. In particular, after identifying promising ideas in their community, students would collectively reflect on their judgments and make decisions on which ideas to pursue next. Such a distinctive pedagogical design conveys the essence of promisingness. Together with technological supports, this design would help to bring students’ knowledge building work into greater alignment with real-world knowledge creation and would also further engage students with the promisingness concept by exposing them to the results of their own promisingness judgments.

5.2.4 Procedures

Both the 2010 and 2011 Grade 3 classes studied “Soil in the Environment” for approximately eight weeks. In studying this unit, both classes followed the Knowledge Building approach as described above. Both classes started with a “KB talk,” with students sitting in a circle sharing their initial questions, ideas, and problems of understanding regarding their understanding of soil. After the first few KB talks interests in both classes focused on two central problems: “what is soil made of?” and “how to make soil?” As is typical in knowledge building exchanges aimed at keeping ideas alive, students recorded select ideas from their conversation in Knowledge Forum so others could build on and in many ways advance them through online dialogues. They contributed to their discourse in various ways including proposing new theories, building on each other’s theories, providing observation results to support their theories, designing and conducting experiments to test hypotheses, and reading and introducing authoritative sources such as books or online materials to improve their theories. As mentioned above, although two classes were led by two different teachers, because of the knowledge building school culture and regular exchanges among teachers, dynamics in two classrooms were both informed by knowledge building principles and reflected the same socio-cognitive paradigm.

In the experimental class, I implemented the promisingness intervention, including
two rounds of promising idea selections that divided the Soil unit into three phases. Below I describe these three phases of the experimental design, involving principle-based pedagogical and technological supports for making promisingness judgments, that were unique to the experimental class.

**Three-Phase Experimental Intervention**

**General design.** The procedures of this intervention in the experimental class is illustrated in Figure 5.2. Following the design of pedagogical supports for promisingness presented in the previous section, this intervention consisted of three main components:

1. *Introduction to promisingness:* This session was aimed at eliciting students’ intuitive understanding of promisingness and improving their understanding through discussion.

2. *Iterative cycles of promisingness judgments:* Judgments made by students in this study affected the course of their knowledge building discourse. As suggested above, they exported ideas to a new view, and did so each time after a promisingness judgment session, so their judgments had direct impact on improvability of ideas over time in a community context. In this intervention, students were involved in two rounds of PJ-export activity, dividing the discourse into three phases, as elaborated below.

3. *Collaborative idea refinement:* Like students in knowledge building classrooms normally do, students in this study also kept refining their ideas collaboratively. This component represents typical knowledge building work.

Across three phases of this study, these three components were interwoven with each other, as elaborated below.

**Phase 1.** As a first step in the current investigation I aimed to start things off exactly as in the comparison class, before starting to explore in greater depth students’
Figure 5.2: Procedures in the experimental class in Study 2. The three-phase design, three different components—collaborative idea refinement/knowledge building, introduction to promisingness, and iterative cycles of promisingness judgments—were integrated together to foster socio-cognitive processes conducive to meaningful promisingness judgments. *Note.* In this illustration, the time dimension is not properly scaled.

understanding of promisingness. Accordingly, for the first two weeks of Phase 1, students proceeded as in the comparison class, participating in collaborative idea refinement through KB talks and working on a view named “Grade 3 Soil 2010/11” in Knowledge Forum.

To make meaningful promisingness judgments students must understand the concept. The first promisingness judgments session took place after collaborative idea refinement. In usual knowledge building fashion, the teacher engaged students in reflections regarding their understanding of a concept—in this case the concept of promisingness. Students, accustomed as they are to KB talks, come to understand that there’s high likelihood that an interesting conversation will ensue from idea diversity. This session contained the following three steps:

- First, a 30-minute introduction to promisingness was presented. Grade 3 students were first asked to brainstorm the meaning of “a promising idea” and “a promising question” in small groups. Students formed 8 small groups, and recorded their thoughts on their group worksheets. Ten minutes later, students brought their thoughts back to a class discussion, advancing different but plausible definitions of the concept and supporting them with meaningful examples. In this discussion, the teacher specifically invited students to ponder on the difference between promis-
ing ideas—ideas that sustain them in design mode work and advance knowledge building—and verified facts; the goal was to help them distinguish promisingness for knowledge advancement from “truthfulness” (found to be commonly confused among primary school students in Study 1). By the end of the presentation of examples and discussion the class arrived at a shared understanding of promising ideas as ideas that “they wish to spend time on,” “may change in further inquiry,” and “would deepen their shared understanding.”

- After the introduction to promisingness, students were introduced to the Promising Ideas tool and then spent 30 minutes using this tool to identify promising ideas in the “Grade 3 Soil 2010/11” view. Figure 5.3 presents an example of a note with one promising idea highlighted, and Figure 5.4 illustrates the top three ideas highlighted in Phase 1. This made up of the second component of the session.

- Finally, the whole class had a discussion on identified ideas, and collectively decided that they should focus on three promising ideas next. To setup Knowledge Forum for next step inquiry, they exported those three ideas to a new view using the tool, and named this new view as “Where does soil come from?” in light of the idea content.

Figure 5.3: A note with one promising idea highlighted within.
Phase 2. Phase 2 of knowledge building started with three weeks of collaborative idea refinement in the new view, followed by a second session of promisingness judgments on new ideas that emerged in this view. During the second round of promisingness judgments, students went through the same idea selection process as in Phase 1, looking for promising ideas in the second view and exporting most promising ones to another new view. This time their interests, reflected by selected ideas, had shifted to earthworms. As a result, they named the third view “Worms and Soil.”

Phase 3. In Phase 3, students worked for another two weeks on the new view, with no further promisingness intervention conducted.

In summary, the three design elements—i.e., introduction to promisingness, iterative cycles of promisingness judgments, and collaborative idea refinement—were integrated together to provide a meaningful socio-cultural context for students’ promisingness judgments. In the process, student notes and selections of ideas were collected for data
5.2.5 Data Sources

To understand student engagement with the concept of promisingness, I conducted extensive quantitative and qualitative analysis of data from the Knowledge Forum database and classroom observations. Knowledge Forum data consisted mainly of student notes and identified “promising ideas.” An overview of the Knowledge Forum dataset is provided in Table 5.1.

Table 5.1: An Overview of Data in Study 2

<table>
<thead>
<tr>
<th>Classes</th>
<th>Views</th>
<th>Notes</th>
<th>Ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010 Grade 3</td>
<td>Grade Three Soil</td>
<td>14</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Worm Anatomy</td>
<td>28</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Worm Life Cycle</td>
<td>36</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Worm Behaviour</td>
<td>38</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Worm Habitat</td>
<td>14</td>
<td>N/A</td>
</tr>
<tr>
<td>2011 Grade 3</td>
<td>Grade 3 Soil 2010/11</td>
<td>39</td>
<td>57</td>
</tr>
<tr>
<td>(experimental)</td>
<td>Where does soil come from?</td>
<td>87</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>Worms and Soil</td>
<td>37</td>
<td>0</td>
</tr>
</tbody>
</table>

During the Soil unit, students from the experimental group worked in three Knowledge Forum views respectively in three phases, as described above; the names of these three views were “Grade 3 Soil 2010/11,” “Where does soil come from?,” and “Worms and Soil.” Students produced a total of 163 notes, 39, 87, and 37 notes respectively in the three views. As for “promising ideas,” I counted each single highlighted sequence of words by any student as one idea. Students identified 57 and 94 “promising ideas” from the first two views during promisingness judgments sessions in Phase 1 and 2. Since several students could independently select a same idea, there were a number of repetitions of ideas. In Phase 3, students did not attempt to make promisingness judgments so no promising idea was highlighted.
In the comparison group, students produced 129 notes in the “Grade Three Soil” view and its four sub-views. Those four sub-views were created by the teacher just for the ease of organizing notes when the “Grade Three Soil” view became messy. Students in the comparison class did not use the Promising Ideas tool or make promisingness judgments, so no ideas were identified as promising.

In addition to data from Knowledge Forum, students’ worksheets from the first session in which they recorded their initial thoughts of promisingness were collected. The eight small groups of students produced 35 notes in this initial session conveying their early thoughts regarding promisingness. Additionally video recordings of pedagogical treatment were collected to triangulate findings related to promisingness understanding.

5.2.6 Data Analyses

An overview of data analysis corresponding to the four research questions of the present study is presented in Table 5.2. Data analysis conducted in this study focused on research questions pertaining to three components in the designed intervention:

Component 1: Introduction to Promisingness

Group notes produced by students in the initial session were coded using a “grounded theory” approach (Glaser & Strauss, 1967). Through an iterative categorization process, key themes of student conception were identified from analysis of students’ group notes and were then gradually refined through cycles of analysis and verification. Video recordings of student discussion during the treatment session were similarly analyzed to triangulate findings from analysis of student notes and also to explain results.

To assess how pedagogical supports designed for promisingness judgments were enacted, videos from the intervention session were analyzed with focus on development of students’ conception of promisingness.
<table>
<thead>
<tr>
<th>Intervention components</th>
<th>Research questions</th>
<th>Data analyses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction to promisingness</strong></td>
<td>1. Do grade 3 students have any awareness of promisingness of their own ideas? What is their intuitive understanding of promisingness?</td>
<td>Analyze students’ initial conceptions of promisingness, by applying the “grounded theory” procedures on students’ group notes during the intervention session</td>
</tr>
<tr>
<td></td>
<td>Subordinate question: How was pedagogical supports for promisingness judgments enacted in the intervention session?</td>
<td>Video analysis of classroom conversations in the intervention session</td>
</tr>
<tr>
<td><strong>Iterative cycles of promisingness judgments</strong></td>
<td>2. Is it possible to raise students’ awareness of promisingness and support them in making promisingness judgments in their knowledge building?</td>
<td>Analyze video recordings of student discussion during the intervention; code epistemic nature of ideas selected by students, according to the “ways of contributing to knowledge-building dialog” scheme (Chuy et al., 2011)</td>
</tr>
</tbody>
</table>
| | 3. How might promisingness judgments influence knowledge-building discourse, at individual, group, and community levels? | (1) Analyze temporal relations between promisingness judgments and other knowledge building behaviors at the individual level  
(2) Case study of inquiry threads produced by small groups of students  
(3) Analyze social networks based on note-reading, building-on, and idea-highlighting activities, and compare social networks between two classes and across different discourse phases |
| **Collaborative idea refinement** | 4. Can promisingness judgments facilitate knowledge advancement in a knowledge building community? | (1) Code scientific sophistication of notes in two classes according to the scientificness scheme (Zhang et al., 2007), and compare scientificness of notes between two classes as well as across discourse phases  
(2) Apply semantic mapping with expert corpora through Latent Semantic Analysis |
Component 2: Iterative Cycles of Promisingness Judgments

Analysis of ways of contributing to knowledge-building discourse analysis. Students in the experimental group used the Promising Ideas tool to select a total of 151 ideas. To investigate their “in-vivo” understanding of promisingness as well as to assess the effectiveness of the pedagogical supports, content analysis (Chi, 1997) was conducted on the epistemic nature of students’ selections of promising ideas. As indicated in Pilot A of Study 1, Grade 5/6 students tended to hold a “fact-oriented” conception of promisingness. The focus of the current analysis was to determine if through reflection, discussion, and clearer teacher explication of the concept of “knowledge building potential” students might have access to a knowledge building potential account of promisingness, and select ideas accordingly rather than because they represent important-sounding facts.

Toward this end, I analyzed the contribution types of the 151 ideas students selected to gain better understanding of their epistemic nature. All identified ideas were coded according to the “ways of contribution to knowledge-building discourse” scheme developed by Chuy and colleagues (2011). As introduced in Study 1, this scheme provides an inventory of students’ types of contributions, with six major categories: formulating thought-provoking questions, theorizing, obtaining evidence, working with evidence, synthesizing and comparing, and supporting discussion. There are also 24 sub-categories, but this study focused on major categories. As elaborated in Chapter 4, the distribution of contribution types represented in selected ideas was used as an indicator of students’ approach to promisingness: obtaining evidence and working with evidence were considered a reflection of a “fact-oriented” conception, whereas theorizing, formulating thought-provoking questions, or synthesizing and comparing were assumed a reflection of a “knowledge building potential” conception of promisingness. Two independent raters conducted the analysis. The inter-rater reliability as measured by joint probability of agreement was .83. Discrepancies were discussed to reach agreement.

The effect of promisingness judgments on socio-cognitive dynamics of knowledge-
building discourse. To determine if knowledge-building discourse was affected by promisingness judgments I analyzed knowledge building activities at both the individual and group levels. First, I tracked students’ individual Knowledge Forum activities and established their individual profiles, with a goal to understand how students made use of PJ's in their work. More specifically, I extracted note reading, note writing, and promising idea highlighting activities by each student, sorted them in chronological order, and applied a temporal analysis (Hannan & Tuma, 1979; Mercer, 2008) to analyze connections of activities of each student profile. Analysis focused on the historical aspect of interactions, tracing the development of ideas in each individual profile to uncover the impact of promisingness judgments on knowledge building activities at the individual level.

Second, I considered the impact of promisingness judgments on the cohesiveness of community knowledge. The idea underlying this design was that promisingness judgments, which led to a group profile of ideas considered by the community to be most promising, help students attend to agreed upon promising directions for their community knowledge and create a more cohesive community context for their work. To explore this possibility, I first analyzed small-group interactions in a number of conceptual lines of inquiry participated by varied numbers of students. Development of ideas was tracked in each line of inquiry, i.e., inquiry thread (Zhang, Scardamalia, Lamon, et al., 2007), and special attention was given to the role PJ's played in advancing these ideas. Case studies of two representative inquiry threads are presented.

Social Network Analysis (SNA; J. Scott, 1988; Wolfe, 1997) was used to analyze knowledge-building discourse at the community level, as reflected in students’ multimodal interaction data recorded in Knowledge Forum. SNA has been widely used in studying the patterns of student interaction in computer-supported collaborative learning (CSCL) and knowledge building (e.g., Chan & van Aalst, 2004; Laat, Lally, Lipponen, & Simons, 2007; Palonen & Hakkarainen, 2000). Instead of studying individual
behaviors, SNA focuses on patterns of interaction, uncovering individual profiles, and investigating the structure of the community. For this analysis three types of interactions involving note reading, building-on and promising idea highlighting, were used to construct social networks. To obtain a general understanding of each network, global level SNA measures were compared across different discourse phases in the experimental class. Among five principles highlighted by Haythornthwaite (1996) for examining social networks, i.e., cohesion, structural equivalence, prominence, range, and brokerage, I focused on cohesion in this study. In this case, cohesion generally refers to the extent to which individual students interact with each other in the community. According to SNA literature, there are a number of measures to assess network cohesion. The concept of network density, which reflects the extent to which students interact with each other’s contributions, is closely related to community knowledge, an important principle of knowledge building (Scardamalia, 2002). Related to density, the measure of average weighted degree, which denotes the average weight of connections among students in the network, was also used to represent how cohesive a network is. The weight of a link between two students, represented as nodes, denotes the strength of their connection. For example, in a building-on network in this study, the weight of a link from student A to B is determined by times student A has built on student B in Knowledge Forum. Therefore, compared to density, average weighted degree can provide a finer measure of how closely students are connected in terms of reading each other, building on each other, and highlighting each other’s ideas as promising. Another important measure to characterize the connectedness of a network is average path length (Abraham, Hassanien, & Snášel, 2009). Briefly speaking, average path length denotes the average number of steps along the shortest paths for all possible pairs of nodes. When applied to knowledge building communities, this measure takes the network structure into consideration and provides another perspective about how democratized or balanced a student network is. For example, a building-on network with a shorter average path length is likely to
have a higher structural equivalence and low brokerage; thus, student discourse tends to be more balanced and symmetric, rather than dominated by a few prominent “leaders.” Therefore, beside community knowledge, this measure is also linked to symmetric knowledge advancement, another important knowledge building principle (Scardamalia, 2002). Network visualizations were also inspected to inform the comparisons of network measures, to explore whether promisingness judgments had contributed to nurturing a more cohesive knowledge-building community.

Component 3: Collaborative Idea Refinement

If making promisingness judgments raises the level of discourse of the community as a whole that will provide support for the idea that promisingness judgments foster idea improvement. To determine the extent to which promisingness judgments facilitated advancement of knowledge, content analysis of Knowledge Forum notes were conducted, comparing experimental and comparison classes, and considering change across discourse phases. For this analysis, student notes in both classes were first coded using the “ways of contributing to knowledge-building discourse” scheme (Chuy, Zhang, et al., 2011), and identified notes under the theorizing main category. To evaluate knowledge advancement in both classes, I then evaluated the level of scientificness of these theorizing notes, using a 4-point scale developed by Zhang and colleagues (2007):

1. *Pre-scientific:* containing a misconception while applying a naive conceptual framework;
2. *Hybrid:* containing misconceptions that have incorporated scientific information;
3. *Basically scientific:* containing ideas based on a scientific framework, but not precise; and
4. *Scientific:* containing explanations that are consistent with authoritative scientific knowledge.
Two coders independently assessed the notes, and the inter-rater agreement as measured by joint probability of agreement was 0.86. A two-way factorial analysis of variance (ANOVA) was performed to assess whether scientific sophistication scores of student notes could be predicted from class membership (experimental vs. comparison), phases of discourse (Phase 1, 2 and 3), and the interaction between these two factors.

Second, latent semantic similarities between student notes and authoritative sources were calculated through Latent Semantic Analysis (LSA) to approximately represent students’ level of collective understanding of the subject matter. LSA is a theory and model for extracting and inferring contextualized, latent meaning of words from statistical analysis of a corpus of text (Landauer, Foltz, & Laham, 1998). It has been widely applied to compare semantic meaning of different documents, and its adequacy in reflecting human knowledge has been established in extensive educational settings (Foltz, Kintsch, & Landauer, 1998; Landauer & Dumais, 1997; Rehder et al., 1998). In LSA, each document is treated as a “bag of words;” comparison between documents is based on latent connections between their words in a pre-defined semantic space trained through complex mathematical computations. To train a semantic space about soil, I first selected four pieces of authoritative sources about soil that represented varied levels of complexity, including the “Soil in the Environment” unit in the Ontario curriculum standards (2007), the Wikepedia article about Soil (2011), an entry level article about soil from US Environmental Protection Agency (2011), and a more sophisticated education article from US Department of Agriculture (2011). Then I exported student discourse in three views to three individual documents, and compared them with the list of authoritative sources for similarity. Similarity scores between student discourse and authoritative sources represented the advancement of community knowledge at different knowledge building phases. Based on these analyses, I would be able to understand the extent to which PJs have facilitated knowledge advancement in knowledge building across three discourse phases.
5.3 Results

5.3.1 Enactment of Pedagogical Supports

Study 1 presented in the previous chapter demonstrated the importance of a supportive socio-cognitive context for introducing promisingness to students. In the present study, in the experimental class, the teacher spent a considerable amount of time eliciting students’ initial conceptions of promisingness and further advancing them through meaningful discussion. In this section, I describe this introductory experimental-class session in detail to provide context for pedagogical and technological supports used in this study.

The PJ session started with students sitting on the carpet and the teacher standing in front of the SmartBoard™ talking to students (see Figure 5.5). At the very beginning of the session, the teacher motivated students to join the conversation by saying:

Teacher (T): Today we are going to be part of a research that no one else in Grade 3 has been looking at. So, I wanted to tell you I am a little bit excited about this and I know I should have probably had a haircut but I did wear this shirt. You are the very first [Grade 3 doing this research]! So, I really want you to work on this for about 45 minutes and I want you to really think, really [be] focused, while we are together.

After successfully grabbing students’ attention, the teacher then introduced the concept of “promising idea” by discussing the meaning of the noun “promise.”

T: The first thing that I want you to do is, very soon, I am going to ask you to go to your table groups, and we have a sheet of paper on each one, in the center, I want you to write down this word, and it is: Promising Idea. When we think of the word “promise”, something, I want to “make a promise,” what do we mean by “making a promise?”

S: You promise somebody that you are going to get something to them...
S: Like something that you will not forget about...
S: Like when you make a promise, you say you are going to do something...
T: So, if you say that you are going to do it, you do it! And if you say you are not going to do it, you don’t do it! Right? What you say is what you are going to do. Okay?
S: Is like something you say ahead of time.
R: Yes, very good! And I like that because that is going to link us to a new understanding of the word “promise.”
Students demonstrated fairly good understanding of the noun. So the teacher moved on and asked students to ponder the meaning of the adjective—"promising"—perhaps more difficult for Grade 3 students.

T: This is "promising" as an adjective. We are going to be describing ideas, and if an idea were to be "promising," if an idea were to "promise" something, it’s a promising idea. I want you to think about what would that be like. [A student hands up.] Just put your hands down for a minute. Just think for a moment: what could that mean if an idea is promising? Or if a theory is promising? Or if a question, a problem, shows promise? Something shows promise? Think about it for just a bit with your hands down... [Pause] Now, what I want you to do is, I want you to go to your table groups, and I want you to write down [what does a promising idea mean] in the center... It doesn’t matter where you are writing on this side of the paper or on this side of the paper. Just sort of write ideas that come up, that help explain that an idea is promising, [or] what could that mean? Just write the first things that come into your mind! Go! Let’s go!

Because this study was interested in uncovering students’ initial understanding of the vocabulary “promising” and the concept of “promising idea,” no more was said before students discussed these concepts among themselves. Students then moved to
small groups, each with 2-3 students, to discuss the meaning of promising ideas and wrote their thoughts down in their worksheets. The teacher and interns walked around and clarified questions raised by students. After 5 minutes of small group discussion, the teacher invited students to think about another question: “what is a promising question?” Without leaving their tables, students kept working in small groups for another 2 minutes. Then the teacher gathered students again to a class discussion, inviting student groups to share what they had written down.

R: So, I would like people, I would like somebody to share, not necessarily the one you wrote down, it could be just one that got written down in your group. So, who would like to share one? [One student hands up.] Go ahead.

S: Promising questions, our group thinks that, something like a proper question, in like it doesn’t have too many answers, that is like, very simple.

S: One proper answer.

S: Our group thought an idea that you are pretty sure is right.

S: Our group thought that a promising question was that you promise that you don’t know.

S: A question you can spend time on?

S: Our group didn’t write it down, but we came up with this, I think a ‘promising question’ is a question that has quality thinking put into it, and you can spend lots of time on it, and it has more than one answer.

S: Part of a different one, it was the opposite, a question that you know the answer.

S: It’s a question that will help you do something...

S: It’s like a very good idea that probably will be right.

The teacher facilitated the sharing process and invited students to share as much as possible. He noticed that students showed diversified, and sometimes contradictory, understanding of what a promising idea or question means. So he stressed that the research was new and tried to make sure students feel safe about sharing their thoughts, even though they might contradict with others.

T: How is it possible that we have people saying promising could mean “you know the answer,” and promising could mean that “you don’t know the answer?” This is why I started by telling you this is brand new research. We are still trying, the researchers are trying to figure out how to best teach this, using the right language. So, yes, let’s hear more ideas...
After eliciting students' initial conception of promisingness, the teacher regathered students to sit on the carpet and tried to further advance their understanding through group discussion.

T: The researchers who have been thinking about this, they have realized that a promising, something that’s promising, like you have identified, something that is interesting, is something that you want to... [Gestures encouraging students to speak out]
S: Go farther with?
T: Yeah! Go farther with. What’s another way to say this? Something you want to...
S: Achieve.
T: Achieve? These are all great. Yes?
S: Find more about it?
T: Find more about it! So, it’s not something that you know necessarily know the answer to.

During the sharing process, the teacher realized a number of students mentioned that “a promising idea is true,” as found in Study 1. So he attempted to tackle this issue by helping students distinguish promising ideas from accepted facts.

T: How about if it is something for example that you absolutely know this. You absolutely know this about something. Can somebody give me an example?
S: One plus one...
T: One plus one is?
S: Two.
T: We absolutely know that one plus one is two. Is that do you think a “promising idea?”
S: No.
T: What would that be? What do we call that? [Pause] In science, when we know something to be absolutely true, all the evidence supports that this is true, we call that... what do you think?
S: A proper answer?
T: Ok, in science we sometimes use the word ‘fact.’ Have you heard that? “That’s a fact!” Can somebody use that in a sentence. Like this is a fact, and tell me something that is a fact. Go ahead.
S: Fire is a fact. No—fire is hot and that’s a fact.
T: Fire is hot and that’s a fact. Do we agree on that?
S: Yes.
T: Do we say that fire is hot is a promising idea?
S: No.
T: Why not?
S: Because it’s obvious that is right.
T: Thank you. We know that already. That’s a fact. So we want, instead, to leave those facts, we know that, that’s great, facts are important, but today we’re interested in “promising ideas.” How are they different than facts? Yes?
S: For a fact is like it has to be true, for an idea, it’s not true, you just think it is.
T: Yeah, could it be true in the end?
S: Yes.

After efforts to distinguish facts from promising ideas, the discussion evolved to focus on what they should do with promising ideas and questions.

T: Let’s say you had a promising question about soil, what could you do to find out about more information? Yes?
S: Books.
T: You could look at books, that’s one thing.
S: What if books are wrong, you can go to the Internet.
T: You can go to the Internet. That’s another thing. What else?
S: You could test it.
T: You could test it, how?
S: By going outside and do an experiment.
T: Yeah, do an experiment, where you might design something... So, those are all ways that you can get information from a promising question. A “promising idea” – Could that idea improve? Could that idea get better?
S: Yes.
T: How? Yes?
S: Say you have an idea [about soil], then you think it’s right, and then you do more research about it, you find out that is not right, that you find something more about it, you can add to it and change it somehow, and is right.
T: And that idea ends up changing a little bit? But, isn’t that important that our original ideas are right?
S: No.
T: What’s important? What are we interested in here?
S: That eventually, you do get it.
T: Eventually you do get it. So that ‘promising idea’ might actually change? Right? It might not be the same idea we end up with. This is the part where now you are going to get to work on.

At this point, the teacher stopped, having addressed a number of challenges in understanding promisingness, with focus on ideas on a promising trajectory rather than true
and warranted belief. While the discussion ended on an “eventually you get it” note, suggesting a more intermediate framework for promisingness than intended, it was likely the teacher’s judgment that it best to end the discussion at this point, considering these are Grade 3 students. Realizing students might feel uncomfortable being evaluated and evaluating each other’s ideas as promising or not, the teacher further stressed the goal of finding promising ideas to help the class as a whole advance understanding.

T: I just want to say something – you might read a note, and when you open that note, you might find, you know, this note has a fact in it, but not a promising idea, that’s okay, that’s fine, then you wouldn’t be identifying any part of that. If you find a note that has one promising idea, great, you’ll identify that part, if you have a note that maybe has two promising ideas in it, we might be able to do that again. Is that correct? We are looking at ‘promising ideas,’ right? If you find that there is a question that somebody has that is a promising question, that would be okay to identify as well. A promising idea is something we want to learn more about, and probably, is going to change.

At this point the pedagogical/discussion phase came to an end.

After the classroom discussion of promisingness, a researcher from my lab demonstrated the Promising Ideas tool and students spent the rest of the class using the tool to highlight promising ideas.

In summary, the teacher elicited students’ initial conceptions of promisingness, clarifying the distinction between “facts” and promising ideas for improvement. In addition, the teacher showed thoughtfulness in ensuring that students felt safe in evaluating ideas and having their ideas evaluated for promisingness by their classmates. From a Knowledge Building pedagogical perspective the pedagogical design implemented under the guidance of the teacher reflected knowledge building principles: eliciting student ideas and treating them with great respect; conveying that ideas are improvable and that improving them is valued, not something to be discouraged about; helping students see productive diversity in ideas and safety in risk taking; and collective responsibility for knowledge advancement. These elements are all important for supporting a knowledge building community, and for the conduct of this research in particular.
Table 5.3: Facets of Student Initial Conceptions of Promisingness

<table>
<thead>
<tr>
<th>Facets</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factual</td>
<td>Group 1: “A true idea” or “an idea that is not incorrect.”</td>
</tr>
<tr>
<td></td>
<td>Group 2: “True.”</td>
</tr>
<tr>
<td></td>
<td>Group 3: “You know that an idea is true”, or “you promise that it is right.”</td>
</tr>
<tr>
<td></td>
<td>Group 5: “An idea that you are pretty sure is right.”</td>
</tr>
<tr>
<td>High-probability</td>
<td>Group 4: “An idea that is very good and probably be right.”</td>
</tr>
<tr>
<td></td>
<td>Group 5: “An idea that might work.”</td>
</tr>
<tr>
<td></td>
<td>Group 7: “This is probably a right idea.”</td>
</tr>
<tr>
<td></td>
<td>Group 8: “Idea that is most likely to be right,” or “90% sure its right.”</td>
</tr>
<tr>
<td>Knowledge building potential</td>
<td>Group 1: “A question you can spend time on.”</td>
</tr>
<tr>
<td></td>
<td>Group 2: “A question you need to know.”</td>
</tr>
<tr>
<td></td>
<td>Group 5: “A question that can help you do something.”</td>
</tr>
</tbody>
</table>

5.3.2 Students’ Intuitive Understanding of Promisingness

Research reported in Chapter 4 showed a bias toward selection of fact-based ideas as promising. Therefore, in the first intervention session reported here, an effort was made to tap the fuller range of ideas that students might bring with them to the understanding of the concept of promisingness. This started with the pre-discussion activity that engaged students in recording their ideas. Students’ group notes, written on their worksheet during the first session, were then analyzed. This analysis led to identification of three conceptions of promisingness (see Table 5.3):

1. **Factual.** Consistent with the results from Study 1, “being true” or “truthfulness” represented a popular account of what makes an idea promising. For example, some students thought a promising idea was “a true idea”, “an idea that is not incorrect”, “an idea you promise that it is right”, or “an idea that you are pretty sure is right”. These account help explain previous results in which students identified as promising facts such as “The universe is 13,000,000,000 years old!” and “the grand canyon could have 912,456 layers of rock”.

2. High-probability of being right. Students recognized ideas with uncertain truth status as promising as long as they had high “likelihood” of being a fact or right. For example, “an idea that is very good and probably be right”, “an idea that might work”, “this is probably a right idea”, or “idea that is most likely or 90% sure to be right”. This notion of “likelihood” went further than purely fact-oriented truthfulness. According to dictionaries such as Merriam-Webster, promising means “showing signs of future success or excellence,” “likely to turn out well,” or “likely to succeed or yield good results.” Bereiter (2002b) explained promisingness by the metaphor of “hill climbing,” highlighting that promisingness evaluation is similar to finding the best way up the hill although you cannot see a path to the summit. In this sense, the notion of “likelihood” students captured is an essential component of promisingness. However, it should be noted that students holding these thoughts were thinking of likelihood in terms of an idea’s current status of being true. Plausibly, they were still not thinking of ideas with a trajectory for growth.

3. Knowledge building potential. Students also recognized as promising those “leading to future actions” and having knowledge building potential. For example, “an idea you can spend time on”, “an idea/question you need to know”, and “an idea/question that can help you do something”. These beliefs are close to the notion that a promising idea could be flawed but worth laboring to be improved (Bereiter, 2002b; Bereiter & Scardamalia, 1993). This link to knowledge building potential provided a good basis to work from for the pedagogical supports, which aimed to engage students in meaningful promisingness judgments to advance knowledge building.

To summarize, prior to discussion regarding the meaning of the concept of promisingness, Grade 3 students in the current study demonstrated access to a range of meanings of the concept, including the full range discussed in this thesis.
5.3.3 Is It Possible to Raise Students’ Awareness of Promisingness and Support Them in Promisingness Judgments to Advance Knowledge Building?

In this thesis I have argued that identifying important-sounding facts reflects a belief-mode, truth oriented conception of promisingness; identifying ideas that contain explanations, theories or hypotheses reflect a design-mode idea improvement conception of promisingness. The analysis just reported suggests Grade 3 students’ intuitive understanding of promisingness includes this range of conceptions, albeit the idea improvement conception is underrepresented. The teacher-led discussion session was designed to give greater prominence to the knowledge building potential conception. With nothing more than this introduction to promisingness students used the PI tool to identify promising ideas in their discourse. An important research question I wished to address was: Is it possible to raise students’ awareness of promisingness as knowledge building potential and, in turn, allow them to make use of this conceptualization in promisingness judgments in their knowledge building? If so, would a relatively simple discussion such as the 30-minute session that was led by the teacher be sufficient?

To answer this question, I applied the ways of contribution scheme described above to students’ selections of promising ideas. If the treatment was effective, students would think of promising ideas with an improvement trajectory, and accordingly highlight more theorizing and less obtaining evidence or working with evidence contributions as promising. Results of analysis are presented in Figure 5.6, presented together with those in Pilot A from Study 1 for comparison.¹ As shown in the figure, Grade 3 students in the experimental class identified a large portion of theorizing (68.9%) and much less

¹The reason why the epistemic nature of ideas highlighted in this study was not compared with Pilot B in Study 1 was because Pilot B employed a customized color scheme that facilitated idea highlighting into different epistemic categories. That design was different from both Pilot A and the current study. As a result, the epistemic nature of ideas highlighted during the current study was more comparable to Pilot A.
obtaining evidence contributions (6.7%) as promising, compared to the 5/6th graders in Study 1. Students in this study also highlighted other contribution types, including questioning (9.8%), working with evidence (4.9%), synthesizing and comparing (1.8%), and supporting discussion (8.0%). Overall, the proportion of fact/evidence has decreased significantly, compared to selections by Grade 5/6 students reported in Pilot A. This finding indicated that students’ conception of promisingness could be advanced, so that rather than focusing on “true ideas” students could perceive ideas as having a promising growth trajectory.

Further analysis of obtaining evidence contributions indicated that similar to two Grade 5/6 classes in Pilot A, most of these contributions in the Grade 3 experimental class were introducing new facts or new pieces of evidence. Because evidence could be introduced to discourse in different ways, I further scrutinized the dialogue context of the highlighted obtaining evidence contributions. This analysis revealed that these highlighted contributions in Grade 3 discourse usually co-occurred with working with evidence contributions; more specifically, evidence or facts in these contributions were...
originally introduced into the dialogue to support or refute a theory. For instance, in an idea identified by one Grade 3 student, the new information “when it’s night it’s cooler... in the day the sun is shining and it’s warmer” was introduced to support her theory that “worms sense light by temperature.” In contrast, as reported in the previous chapter, fact/evidence contributions identified by Grade 5/6 students, who were not engaged in discussing the meaning of promisingness, were more likely to be standalone. Grade 5/6 students were more likely to identify standalone facts such as “the solar system formed 4570 million years ago.” Possibly students from the Grade 3 experimental class were identifying obtaining-evidence contributions that were helping to drive their discourse forward, while Grade 5/6 students saw in them some sort of distinctive “attractiveness.”

5.3.4 How Might Promisingness Judgments Influence Knowledge-Building Discourse, at the Individual, Small Group, and Community Levels?

Individual-Level Knowledge-Building Discourse

As promisingness evaluation is an integral component in knowledge-building discourse, I analyzed its relations with other knowledge building activities at the individual level. This analysis focused on qualitative data from each student’s note writing and promising idea highlights. As explained in Section 5.2, notes and highlighted ideas by each student were sorted in chronological order to establish student profiles. Temporal analysis considering the interplay between PJs and other knowledge building behaviors was then considered to uncover each student’s profile. This qualitative analysis identified the following four major themes of promisingness judgments by Grade 3 students in the experimental class:

(a) Ideas highlighted as promising were usually relevant to ideas posted by themselves, and could result in knowledge revisions or integrations. As
students were participating in collaborative knowledge building, they usually brought along their own interests in idea highlighting. As a result, most ideas highlighted by students were relevant to ideas posted by themselves.

To investigate how the actions of highlighting promising ideas affected one’s knowledge building activities, I analyzed subsequent notes written by a student after she highlighted each promising idea. First, identified ideas were linked to rethinking ideas, and eventually to revisions. For example,

S9 posted her first note about “how worms sense light”: “My theory is because we have a sense of up and down worms have a sense of light and dark.”

A few days later, she identified a promising idea written by S6 that “the worms feel heat and the light has heat and dark doesn’t!”

In the next note she wrote, “My theory is that it also has something to do with heat. Like when you walk into the dark it gets colder because there’s less sunlight... They don’t need eyes because they can feel heat like us.”

Plausibly, she revised her original thought based on a simple analogy to a more sophisticated idea leading to more coherent reasoning.

In some other cases, highlighted ideas that complemented or enriched one’s own ideas resulted in efforts of integrating them into more advanced explanations. For example,

S13 firstly posted a note, “My theory is that soil is made out of rocks that get turned into sand. then you maybe take a little bit of grounded up wood. You take a little water then a little sunshine and there is your soil!”

Then she picked an idea from S8, “the soil is made from rocks it gets all broken up from the wind and getting rain or something watery on it.”

In the next note she tried to integrate the highlighted idea into her original one: “My theory is that soil is dirt, rocks, little bits of water and life. The
rocks get smashed up. Then mix it with the dirt. Then add water to make it moist. the worms help the soil and the poop and the worms make air holes.”

In summary, by engaging students in the intentional process of identifying promising ideas in the community, their attention could be raised to interconnected ideas that might otherwise be neglected. This process of considering multiple perspectives and formulating increasingly interconnected views of scientific concepts serves as at the heart of symmetry knowledge advancement (Scardamalia, 2002), knowledge integration (Linn, H.-S. Lee, Tinker, Husic, & Chiu, 2006), and conceptual change (Vosniadou, 1994) in science learning.

(b) Intentional tagging of promising ideas drew students’ attention to new, emergent topics leading to increased participation. In addition to the analysis of the impact on personal understanding, I also analyzed the extent to which promisingness judgments affected collaboration. Results showed various types of participation after a promising idea is highlighted. In a few cases students participated by simply agreeing upon or repeating a highlighted idea. On most occasions, students could contribute insightful ideas and substantially improve their group’s shared understanding. For example,

S2 had not posted any note before highlighting an idea about “worms”: “the worms feel heat and the light has heat and dark doesn’t.”

A few days later, he posted a note with an alternative explanation, “My theory is that worms don’t have eyes they can sense the difference between soil and the outside world. Because they can feel the difference in humidity.”

One week later, he further developed his idea and came up with a scientific explanation, “worms don’t have eyes they have photo-receptors which catch the light and if they go outside too long the photo-receptors will shoot off and the worms will get paralyzed...”
These new contributions led a few other students to grapple around the scientific concept of “photoreceptor” and helped boost knowledge advancement of the whole group.

(c) While promisingness judgments could lead to participation and idea improvement, it was also common that students failed to act upon identified promising ideas. As results showed, some students highlighted a number of ideas but did not build on or make reference to any highlighted ideas. On the other hand, students might identify ideas that seemed to be interesting but were actually irrelevant to their own ideas. In this case, students highlighted ideas without the intention to further develop them. For example, S20 was the most active student in identifying promising ideas in this intervention. She identified 35 ideas in two sessions of promisingness judgments. However, a lot of ideas she highlighted were contradicting with each other; they almost represented all key explanations emerged from the class. Moreover, in her writing she did not make any effort to sort or integrate different explanations to achieve any explanatory coherence. This finding was consistent with Study 1, in both pilots of which I found students active in highlighting but with less engagement with the promisingness concept (see Section 4.3.1 and 4.4.1). A similar situation happened with S8, who highlighted a number of ideas about “where does soil come from,” but did not post any note related to that question. Thus, while in many cases students could work creatively with identified promising ideas, they may need additional scaffolding in this area.

(d) Individual variation in making promisingness judgments. Some students had a fairly good sense of promisingness, highlighting ideas leading to promising and fruitful directions, as presented in subsequent sections. For example, a number of students, such as S9, S16, S17 and S19, showed a strong sense of promising directions in their discourse. Most ideas they picked could represent the cutting-edge issues in the class, and as shown in examples above, some of those identified ideas got further developed and led to conceptual breakthroughs for the whole class.

On the other side, however, some students identified simple facts or already heavily
discussed questions as promising. For example,

S7 and S8 picked the leading question posted by the teacher even if it had been discussed by the whole class for a long time.

S5 and S11 identified a few simple facts as promising ideas, such as “some reptiles live in wet places”, which did not lead to any conceptual breakthrough in their discourse.

Moreover, students also differed on number of attempts in making promisingness judgments ($M = 9.73, SD = 8.71$). To investigate possible relation between promisingness judgment attempts with other knowledge building behaviors, I correlated the frequency of promisingness judgments with other knowledge building activities. Results indicated that the amount of promising ideas highlighted by a student was significantly correlated with number of notes written ($r = .62, p < .01$) and read by the student ($r = .53, p < .05$). Generally speaking, the more active a student in reading or writing notes on Knowledge Forum, the more promisingness judgments she is likely to practice. However, because earlier analysis linked hyper active highlighting behaviors with less relevance with promisingness, the correlation between PJs and other Knowledge Forum activities did not imply students reading or writing more notes led to making more promising judgments.

Furthermore, it also should be noted that some students gradually developed a habit of promisingness judgments in knowledge building. For example, a few students became active users of a newly designed Knowledge Forum scaffold\textsuperscript{2}—“A promising idea”—in writing their own notes, and a few students spontaneously used the tool to highlight promising ideas in later grades without any prompt from the teacher.

Overall, students’ capability in making promisingness judgments varied, and further

\textsuperscript{2}Scaffolds are designed to function like sentence starters in Knowledge Forum. They give ideas defined roles in knowledge processes, and encourage different ways of contributing to knowledge-building discourse. Examples of popular scaffolds include “My theory”, “I need to understand”, “A better theory”, and so forth.
research is needed to find out which factors, such as content knowledge and epistemic beliefs, may contribute to this difference.

**Impact of Promisingness Judgments on Small Group Dynamics: Case Studies of Inquiry Threads**

As shown in the analysis of individual student behaviors, promisingness judgments could encourage idea integration and emergent participation of individuals. It would be interesting to investigate interactions at the group level. To investigate whether and the extent to which promisingness judgments could boost conceptual breakthroughs at the group level, further analysis focused on inquiry threads. Two threads, which represent improvable and successful practices of promisingness evaluation, are presented below, to demonstrate the role PJs could possibly play in knowledge-building discourse.

The first thread illustrates a dialogue from the comparison class where promisingness evaluation was not part of their work. This thread, lasting for three weeks, was one of the most engaging discussions in their Knowledge Forum database, as judged by the level of participation. As shown in Figure 5.7, this thread was initiated by S1’s question of “What are worms made of?” This initial question was situated in a broad interest in “worms” emerging from their study of “soil.” When posing this question, S1 also provided a possible explanation that “a worm is basically a muscle with a vein,” based on her observation that “a worm has no bones.” After this question was posed, a student quickly came up with an alternative explanation that “worms are made of thick glue that holds things together and a layer of skin on top.” Later on, S3 introduced new information that “worms are made of annuli.” However, this contribution was not picked up by the group and the discussion went in another direction that focused on “whether worms are all brain.” A number of students provided their counter-arguments that worms should not be all brain—arguments such as “not all brain because brain is fragile,” “it would hurt when they move,” “they do not feel bumpy,” or “if they are all brain they
would be smarter than us.” There was little progress in this worm-brain discussion and students never revisited the concept of “annulus.”

The second thread came from the experimental class (see Figure 5.8). Similar to the comparison class, students became intrigued by “worms” in their study of soil. The present thread focused on “whether worms have eyes.” This thread, which lasted for an equivalent amount of time as the first thread, was from the “Worms and Soil” view produced by Phase 3 of their knowledge building.

The first distinctive feature of this thread was its origination from students’ promissiveness judgments. In the “Where does soil come from” view students worked on in Phase 2, worms emerged to be a shared interest among students. In that view, students collectively identified a list of promising ideas and elected the top three to be exported to this new view. The initial question in this thread—i.e., “how worms tell the difference between light and dark”—was one of their selected promising ideas.
<table>
<thead>
<tr>
<th><strong>T:</strong> I need to understand: how worms tell the difference between light and dark? Do they have eyes?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S7:</strong> I think that worms feel heat and the light has heat and dark doesn't!</td>
</tr>
<tr>
<td><strong>S4 &amp; S18:</strong> My theory: is that they feel the brightness of the moon and then since the moon is so bright they feel the light and then they know it's day time.</td>
</tr>
<tr>
<td><strong>S3:</strong> My theory: is that worms don't have eyes they can sense the differences between soil and the outside world. Because they can feel the differences in humidity.</td>
</tr>
<tr>
<td><strong>S10 &amp; S14:</strong> My theory: is because we have a sense of up and down worms have a sense of light and dark. Like when we have been in the dark for a long time when you come out even when your eyes are closed you can still feel the light.</td>
</tr>
<tr>
<td><strong>S10 &amp; S14:</strong> My theory: is that it also has something to do with heat. Like when you walk into the dark it gets colder because there's less sunlight, and when you're in light it's warmer because there's more sunlight. They don't need eyes because they can feel heat like us. Light and dark and warm and cold are kind of the same because light is warm and dark is cold.</td>
</tr>
<tr>
<td><strong>S19:</strong> My theory: Is that they have a sense of the light of light and dark. They feel heat in the light, and they feel coolness when they're in the dark.</td>
</tr>
<tr>
<td><strong>S7:</strong> I need to understand: if worms have eyes my theory is that they don't because: 1. if they did the soil would get into their eyes unless their eyes had see-through membranes on them to stop that but that would be too complex for worms. The second reason is that worms are too primitive to have eyes. That's why I think that they have a special sense.</td>
</tr>
<tr>
<td><strong>S3 &amp; S19:</strong> The evidence shows that: worms do not have eyes. they have photoreceptors in their skin!</td>
</tr>
<tr>
<td><strong>S20:</strong> My theory: is that worms have a fifth sense instead of vision. Platypi have a sixth sense instead of five senses like other living creatures. The worms five senses is electro charges.</td>
</tr>
<tr>
<td><strong>S10 &amp; S14:</strong> I need to understand: what are electro charges?</td>
</tr>
<tr>
<td><strong>S8:</strong> My theory: is that they little electrc charges.</td>
</tr>
<tr>
<td><strong>S21 &amp; S2:</strong> My theory: is that electro charges are the thing that send out electricity and they bounce off the object and go back.</td>
</tr>
<tr>
<td><strong>S21 &amp; S2:</strong> My theory: is that they are guided by heat.</td>
</tr>
<tr>
<td><strong>S19 &amp; S13:</strong> My theory: is their skin senses the heat, and the cold. }</td>
</tr>
<tr>
<td><strong>S7 &amp; S17:</strong> The evidence shows that: worms don't have eyes because they have photoreceptors we have those in our eyes. Photoreceptors sense the light so the worms can move. The light patterns show the worms where to go! Heat is in the light and the photoreceptors also help them to sense heat.</td>
</tr>
<tr>
<td><strong>S3:</strong> Worms don't have eyes they have photoreceptors with each the light and if they go out side to look the photoreceptors will shot off and the worms will get paralyzed. the worms will not mind red light but hate blue and white light.</td>
</tr>
<tr>
<td><strong>S7:</strong> My theory: is they might be able to do that with their skin?</td>
</tr>
</tbody>
</table>

Figure 5.8: Inquiry thread 2, from the experimental class in Study 2.
After being exported to this new view, different explanations started to emerge. For example, S7 proposed that worms sense light by heat, because “light has heat and dark doesn’t.” S3 proposed an alternative explanation that “worms sense the difference between soil and outside world based on humidity.” S10 and S14 argue that it is just an intuitive sense of worms, just like human’s sense of up and down. Students especially discussed the problem of “whether worms have eyes.” S7 conjectured that they should not have eyes because their eyes could be damaged in soil and they are too primitive to have eyes. S3 and S19 later introduced authoritative sources that explains “worms uses photoreceptors on their skin rather than eyes to sense light.”

Looking back into this discussion, student discourse gradually evolved from naive but still plausible “temperature-guided sensing” to more scientific “photoreceptors.” In this process, a number of students were active highlighting promising ideas and bringing in thoughts from other threads. It was evident that some students have achieved considerable knowledge advancement. For example, S7 initially made the connection between temperature and light and further defended this idea with three reasons; later she brought in the evidence that worms do not have eyes but sense light by photoreceptors, and further questioned where the photoreceptors should be located. At the group level, the knowledge progress should be attributed to a number of students. They contributed different perspectives to the dialogue, which supported or eliminated different explanations and allowed the discourse to move forward. In particular, promisingness judgments—made by a number of students in the group—have played an important role in this advancement. First, promisingness evaluation has directed students’ attention to this topic during the promisingness judgment session at the end of Phase 2. Second, collective reflection on the promisingness of community ideas attracted attention of not only students who had been working on this topic from the beginning, but also those working in other domains. By identifying a new direction for the group as a whole and bringing students’ attention to promising ideas, discourse became sustained and productive.
Unfortunately, promisingness judgments were not really available to students during Phase 3, when the inquiry thread was in progress. As a shortcoming of design, promisingness judgments in this study had delayed impact on knowledge-building discourse—only when a class-wide deliberation occurred—rather than being closely integrated with discourse to direct group attention on an ongoing basis.

Nevertheless, by comparing these two threads, it became evident that collective promisingness judgments integrated with continuous efforts to further improve identified ideas could lead to substantial conceptual breakthroughs, while discourse with no efforts to discriminate promisingness of ideas could engage students in generation of interesting ideas, but no obvious effort to bring those ideas to some more advanced state.

Community-Level Knowledge-Building Discourse: Inspecting Social Dynamics in the Knowledge Community

Because knowledge building is a collective enterprise, in addition to analyzing individual students and group dynamics, I also studied the impact of promisingness judgments on social interactions within the knowledge community. To this end, SNA was conducted on three types of interaction in two classes—i.e., note reading, building on, and promising idea highlighting. To evaluate how social dynamics changed over time for the experimental group, I partitioned discourse data into three sections according to the three discourse phases. For each type of interaction, corresponding Knowledge Forum log data was exported, analyzed, and then represented as a student network, in which students in the class were denoted as nodes and interactions among them were drawn as edges connecting nodes.

Table 5.4 presents results of analysis related to network-level SNA measures. By comparing networks of different types of interactions, I found the number of edges, density and average weighted degree in note-reading networks were much higher than building-on and idea-highlighting networks. This result was not surprising because reading activities
Table 5.4: Measures of Social Networks in the Experimental Class

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Phases</th>
<th>Nodes</th>
<th>Edges</th>
<th>Density</th>
<th>A.W.D.</th>
<th>A.P.L.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading</td>
<td>Phase 1</td>
<td>20</td>
<td>121</td>
<td>0.32</td>
<td>47.90</td>
<td>12.42</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>20</td>
<td>199</td>
<td>0.52</td>
<td>87.80</td>
<td>4.99</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>20</td>
<td>144</td>
<td>0.38</td>
<td>41.20</td>
<td>7.56</td>
</tr>
<tr>
<td>Building on</td>
<td>Phase 1</td>
<td>20</td>
<td>37</td>
<td>0.10</td>
<td>4.20</td>
<td>11.71</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>20</td>
<td>59</td>
<td>0.16</td>
<td>7.80</td>
<td>8.76</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>20</td>
<td>27</td>
<td>0.07</td>
<td>2.80</td>
<td>16.50</td>
</tr>
<tr>
<td>Idea</td>
<td>Phase 1</td>
<td>20</td>
<td>61</td>
<td>0.14</td>
<td>6.71</td>
<td>1.71</td>
</tr>
<tr>
<td>Highlighting</td>
<td>2</td>
<td>20</td>
<td>57</td>
<td>0.14</td>
<td>9.14</td>
<td>1.86</td>
</tr>
</tbody>
</table>

Note. A.P.L. means average path length, and A.W.D. denotes average weighted degree.

are usually more frequent than note writing and idea highlighting.

Comparisons of social networks across different phases indicated both reading and building-on networks showed increasing levels of connectedness or cohesion from Phase 1 to Phase 2. For instance, the number of edges and the degree of network density increased, showing higher level of connectivity. The average weighted degree in the reading network increased dramatically from 47.9 to 89.8, implying students were much more active in reading each other’s contributions. At the same time, their building-on activities, represented by the average weighted degree in the building-on network, also increased, revealing a higher level of collaboration. The average path length in both network decreased, showing social networks were getting more symmetric and balanced from Phase 1 to Phase 2. It should be noted that those measures were not very high in Phase 3 of the experimental class, possibly because the students worked in this phase for only two weeks while spending three weeks in the first two phases. Of course it could also reflect limited capacity for sustained knowledge building under the current circumstances. In any event, for the following analysis Phase 3 was left out in the comparisons.

As for the idea-highlighting networks, it was interesting to find while the networks had equivalent numbers of edges in Phase 1 and Phase 2, the average weighted degree increased. This phenomenon indicated students were making more promisingness evaluation attempts. However, because the average path length did not necessarily decrease,
the idea-highlighting network did not consequently get more balanced. These results support the finding of considerable variation in PJs from the analysis of individual behaviors, showing some students made significantly more PJ attempts than others.

To further interpret these differences between social networks revealed by SNA measures, I further visualized these social networks using a force-directed layout (see Figure 5.9). Note reading networks were not included because the density of this type of network was quite high in all phases and their structures were similar. Networks in Phase 3 were also left out of this analysis because, as mentioned above, students in the experimental class worked for a significantly shorter amount of time in that phase. In these visualizations, the size of a node denotes its out-degree, weighted number of edges originated from the node. An edge starts from its darker/wider side and ends on its lighter/narrower side. Because all analyzed social networks are directed networks, both ends of an edge can be dark and wide when the bidirectional linkages between two nodes are strong.

As indicated by the visualizations, the building-on networks clearly got denser from Phase 1 to 2. In Phase 1, five students were not connected at all, meaning that they were not building on or being built on during that phase. In contrast, the Phase 2 building-on network was much cohesive. Only one student was still not connected. As reflected by the size of each node (which denotes out-degree), students were much more active building on each other’s ideas. The links between students also got denser and balanced, indicating higher level of collaboration and symmetry of knowledge advancement. Because they started this view by exporting three promising ideas they identified from the previous view, collective efforts were brought together to advance them from the very beginning. As their discussion got deeper, the inquiry was not narrowed to the exported promising ideas; rather, as indicated by previous analysis, they moved to a number of emergent topics such as “how worms sense light,” which evolved to be the promising directions they identified for the next phase knowledge building. Thus, the collective efforts of
Figure 5.9: Building-on and idea-highlighting networks in Phase 1 and 2 in the experimental class. In each visualization, the size of a node denotes its out-degree. An edge starts from its darker/wider side and ends on its lighter/narrower side, denoting the direction and weight of connection.
promisingness judgments helped bring community attention to shared problems, engaging students in more collaborative work, and furthering new problems and ideas.

The idea-highlighting networks in both phases did not show substantial difference but one noticeable difference related to a few students (e.g., S20) who became more active in highlighting promising ideas in Phase 2, demonstrated by the size of their nodes. Another interesting observation was that students receiving a number of highlights were not necessarily active in highlighting ideas, and vice versa. For example, as shown by their incoming and outgoing edges, S8 and S14 received multiple highlights from others in Phase 2 but were not active in PJs themselves; it was the same case for S4 in Phase 1. This finding confirmed the disparity identified in Section 4.4.5 of Study 1. Moreover, these visualizations also showed changes of individual students’ PJ activities across phases. For instance, S19 became more active in Phase 2 whereas S8’s PJ attempts decreased.

In summary, the social network analysis of knowledge building activities in the class identified a possible effect of promisingness judgments in promoting connectedness among students and among ideas. As indicated in the network-level SNA measures, cohesiveness of the building-on network increased across phases of the promisingness intervention in the experimental class. Further analysis of social network visualizations, coupled with interpretation of student dialogues, found promisingness judgments facilitating collaboration by bringing student attention to shared problems and promoting emergence of new problems in increasingly deepening inquiry.

5.3.5 Can Promisingness Judgments Facilitate Knowledge Advancement in a Knowledge Building Community?

Scientificness

The ultimate goal of promisingness judgments is to boost community knowledge by re-focusing community attention on promising directions emerging in ongoing discourse.
Evaluating the promisingness of their own ideas engages students in reflection on the state-of-the-art of their knowledge work and helps them recognize ideas that they deem worth extended efforts. In this way, students could devote their limited time and energy to more promising ideas, with more opportunities for individual and collective understanding to grow.

In this study, our hypothesis was that students in the experimental class, making promisingness judgments, would achieve greater knowledge advancement than students in the comparison class. To test this hypothesis, the scientific sophistication of student ideas was examined in these two groups by rating students’ theorizing contributions according to a scientificness scheme with four levels from pre-scientific to scientific understanding. In the experimental class, 91 theorizing notes were identified and analyzed: 26 notes from “Grade 3 Soil 2010/11” (view 1), 42 from “Where does soil come from” (view 2), and the remaining 23 from “Worms and Soil” (view 3). In the comparison class, a total of 68 theorizing notes were identified. Because the comparison group did not integrate promisingness judgments into their discourse, there was no natural separation of different phases; so student notes were sorted by the time of creation and manually divided them into three phases with equivalent number of notes.

A 2 (Group) × 3 (Discourse Phase) factorial ANOVA was performed to assess whether scientificness scores of student ideas could be predicted from student group (experimental vs. comparison), phases of discourse (Phase 1, 2 and 3), and the interaction between these two factors. The results of the ANOVA are presented in Table 5.5, and mean scores and standard deviations for three discourse phases in both classes are illustrated in Figure 5.10. The analysis of variance found a significant main effect for discourse phases, $F(2, 153) = 14.33, p < .001, \eta^2 = .16$, indicating the mean scientificness scores were different among three phases. The main effect for group difference was not significant, $F(1, 153) = .03, p = .87$. However, the analysis revealed a significant interaction between discourse phases and student group, $F(2, 153) = 3.81, p < .05, \eta^2 = .05$. This
interaction is graphed in Figure 5.10, which shows a steeper gradient of improvement in the experimental group. This finding is important in that the comparison favored the comparison group taught by a more experienced Knowledge Building teacher.

Table 5.5: Group × Phase Factorial Analysis of Variance for Scientificness

<table>
<thead>
<tr>
<th>Source of variance</th>
<th>Df</th>
<th>F</th>
<th>Partial η²</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>1</td>
<td>0.03</td>
<td>.00</td>
<td>.871</td>
</tr>
<tr>
<td>Phase</td>
<td>2</td>
<td>14.33</td>
<td>.16</td>
<td>.000 ***</td>
</tr>
<tr>
<td>Group × Phase</td>
<td>2</td>
<td>3.81</td>
<td>.05</td>
<td>.024 *</td>
</tr>
<tr>
<td>Error</td>
<td>153</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* *p < .05. *** *p < .001.

Figure 5.10: Change of scientificness of ideas in the experimental and comparison class.

**LSA with Expert Content**

To further explore the changes of community knowledge in the experimental group, Latent Semantic Analysis (LSA) was applied as another distinctive analysis technique. LSA was used to identify semantic similarity between two documents within a semantic space.
In this analysis, student notes in three different views were exported to three individual
documents, and then each compared with authoritative sources about soil. LSA semantic
similarity scores between student written dialogues and authoritative sources were used
to infer students’ levels of understanding in different phases. Because view 3 (“Worms
and Soil”) in the experimental group focused on worms rather than soil, only view 1
(“Grade 3 Soil 2010/11”) and view 2 (“Where does soil come from?”) were included into
this analysis. A view (“Grade Three Soil 2009/10”) produced by the comparison group
was also included for comparison. Figure 5.11 presents LSA cosine similarity scores of
three views compared to four authoritative sources dealing with soil, including Ontario’s
curriculum standards, a Wikipedia article, US Environmental Protection Agency (US
EPA) article, and US Department of Agriculture (US DA) article.

From this analysis a pattern emerged: the similarity-with-authoritative-sources scores
of Phase 2 of the experimental group ($M = .24$) were substantially higher than Phase
1 ($M = .08$). The similarity scores of Phase 2 were even higher than the comparison
group ($M = .18$) taught by a more experienced Knowledge Building teacher. By tri-
angulating across different authoritative sources, this analysis showed that students in
the experimental class were posting content semantically closer to expert sources over
time, reaching similarity scores higher than those for the comparison group. As shown in previous analysis of threads, as students pursued deeper explanations, they were using increasingly more complex concepts, e.g., photoreceptors, seemingly drawing their discourse semantically closer to expert corpora.

5.4 Discussion

This study aimed to improve on results from the pilot studies reported in Chapter 4, in line with the design-based research principle of iterative refinement. Design improvements over earlier experiments included introductory pedagogical supports to engage students in discussion regarding various meanings of promisingness. This proved effective in uncovering a range of interpretations from fact-based to knowledge-building potential, all seemingly accessible to students in Grade 3. In addition, technological supports enabled students to highlight promising ideas, with their selections meaningfully integrated into their ongoing knowledge building discourse to support more active participation and deeper knowledge advancement.

5.4.1 Major Research Findings

Design improvements for this study addressed four research questions focused on understanding students’ intuitive understanding of promisingness; raising understanding of promisingness; enabling students in Grade 3 to make promisingness judgments that would productively influence their knowledge-building discourse at individual, group, and community levels; and facilitating knowledge advancement in a knowledge building community. Analysis of students’ written definitions of promisingness, produced in advance of a teacher-led discussion of the concept of promisingness, demonstrated that Grade 3 students could access a range of meanings of the promisingness concept. Most students presented a “truthfulness” interpretation but several presented definitions
suggesting awareness of a “knowledge building potential” conception. Their different accounts in this earliest phase, and then later in class discussions, allowed them to consider a broad range of contrasting interpretations. After the teacher clarified that the “knowledge building potential” account was important for the work they were going to be engaged in, students used the Promising Ideas tool to identify ideas in their Knowledge Forum work. Through a variety of analyses it was possible to show that promisingness judgments led to more productive discourse as well as facilitating productive community-based knowledge work.

These findings were reflected in the following analyses and results. Analysis of the epistemic nature of ideas identified by students found a much larger portion of theorizing ideas than fact/evidence contributions compared with previous studies, suggesting the socio-cultural process implemented was effective in promoting students’ understanding of promisingness. This was the case even for students as young as Grade 3: rather than focusing on “true ideas” students shifted focus to more work with ideas having a promising growth trajectory. From a different angle, Grade 3 students’ competency in making promisingness judgments were uncovered by engaging them in discussing the concept of promisingness.

I further investigated the impact of promisingness judgments on knowledge-building discourse. Temporal analysis at the individual level found ideas identified by the student often related to those posted by themselves and resulting in knowledge revisions or integrations. By grappling with multiple perspectives, students reformulated increasingly interconnected views about scientific concepts, which served as building blocks of knowledge integration and conceptual change in science learning. The intentional effort of highlighting promising ideas also brought students’ attention to new, emergent topics and led them to participate in a variety of ways. After highlighting an idea, while in some occasions students failed to act upon this idea or simply posted a repeating idea, many times students could commit themselves to this idea and made efforts to improve
it. Individual differences were evident among students in their ability to make promisingness judgments, which was found to be correlated with knowledge building activities, including note writing and reading.

Through discourse analysis and Social Network Analysis (SNA), I examined possible impact of promisingness judgments on social dynamics of knowledge building. By comparing two representative inquiry threads, I found that collective promisingness judgments integrated with continuous efforts to further improve identified ideas could lead to substantial conceptual breakthroughs, whereas discourse with no efforts to discriminate promisingness of ideas could leave students generating interesting ideas but not making progress in addressing issues they raised. At the community level, I compared network-level SNA measures and network structure of note-reading and building-on networks across three discourse phases in the experimental class. As indicated in the network-level SNA measures, cohesion of the building-on network increased across phases of promisingness intervention. Analysis of network structure, coupled with interpretation of student dialogues, indicated that promisingness judgments facilitated collaboration by bringing student attention to shared problems and promoting emergence of new problems in knowledge building. These findings at the community level tended to support these at the individual level. When the practice of identifying promising ideas motivates individual students to build on, revise and extend interested ideas, this fosters collaboration in the knowledge building community, with new ideas emergents of the interaction and the community becoming more cohesive.

Comparisons of scientific sophistication of student ideas across discourse phases as well as between classes found the experimental class achieving greater knowledge advancement than the comparison class. The experimental class, who integrated promisingness judgments into their knowledge building, advanced beyond the level of the comparison class in work on the Soil unit, even though they started with slightly less scientific ideas. Additional semantic mapping with expert corpora supported results of content analyses. This
finding of knowledge advancement could be attributed to the synergy of continual reflection on the state-of-the-art of knowledge building, individual and collective commitment to promising ideas, and emergent collaboration—all largely facilitated by promisingness judgments in this study.

Promisingness judgments are thought to play an essential part in creative action and problem solving (Bereiter & Scardamalia, 1993). Informed by prior explorations, this study experimented with socio-cognitive processes to enculturate students into making promisingness judgments and working with those ideas to foster knowledge advancement. Through interventions that integrated principle-based pedagogical and technological affordances for promisingness, students as young as 8 to 9 years old could grasp the essence of promisingness and make promisingness judgments that led to richer collaboration, more cohesive community, and greater knowledge advancement.

5.4.2 Limitations of Study 2

The present study suffered from several limitations. First, the use of a comparison class rather than a controlled class meant that I had little control over course content and classroom organization in the comparison and experimental classes. However, as explained earlier knowledge building as a principle-based innovation (Zhang, Hong, et al., 2011) functioned in School A for almost two decades; regardless of possible difference in learning experience, the core principles that guided knowledge building in both classes were the same.

The second limitation of this study was the short duration of the investigation, especially Phase 3 in the experimental class, thus hampering the comparison of social networks across phases and limiting the knowledge building potential of the intervention.

Third, face-to-face classroom discussion occurred in the two classes. Although I captured videos during the promisingness intervention, videos of “KB talks” were not available, so I had no way to make connections between face-to-face and Knowledge Forum
Chapter 5. Study 2

discourse to provide a more accurate account of knowledge building.

5.4.3 Lessons Learned from Study 2

Despite design improvements that led to encouraging research findings, supports for student promisingness judgments could certainly be improved, and I turn to a discussion of challenges and further refinements in this section.

Postponed Influence of Promisingness Judgments

In this study, the three-phase process segregated by two sessions of PJs provided an opportunity for PJs to have an impact on knowledge building processes. The possibility of impact was increased through procedures such as collaborative review of PJ results at the end of each discourse phase, as well as the collective deliberation on which ideas the community should focus on next. However, promising ideas were held in the aggregation window, thus inhibiting more constant and interactive work with them. This design tended to postpone the influence of PJs till the end of each phase, while making PJs almost invisible throughout much of community knowledge-building discourse.

To make promisingness evaluation a more integral part of knowledge-building discourse, perhaps designs of PI could be improved in two ways. First, visual cues of highlighted promising ideas could be further added to Knowledge Forum to signal status of promisingness in the knowledge space. This change could help direct community attention to PJs on a regular basis, without requiring the community to go through intensive group deliberation processes. Second, more agile idea exporting could also be implemented so that students could have the choice of immediately sending identified promising ideas to designated spaces for knowledge building. Of course, further pedagogical supports around them will be necessary if these new functions were implemented.
Being Blind to Student Thoughts behind Promisingness Judgments

Another challenge in Study 2 was related to the fact that students had no way to express why they highlighted a promising idea. This created a challenge for both students and researchers. For students, during group deliberation they could have a hard time trying to recall the reason for highlighting a specific idea. And because their reasoning was not made explicit, extra time was needed to discuss ideas in the aggregation window. While students might use the search function to pull together related ideas by certain words, this search function is limited and less effective than directly capturing students’ perspectives.

From research and pedagogical perspectives, individual variation in use of the PI tool and follow up work raises many questions. In both Study 1 and 2, I found some students highlighting a large number of ideas that had no discernible trace of promisingness. It would be intriguing and necessary to further investigate the thoughts behind their PJs in order to understand their processes and design additional supports. But students’ thoughts were not captured, so this study offers little insights in this area.

Future PI designs could perhaps offer students the option of expressing their thinking during PJs. For instance, PI could prompt students to explain why they selected an idea or which topic an idea is promising for, so that during group deliberation promising ideas could be easily brought to focal attention. However, this possible change would impose additional cognitive load on students, although effective designs might limit that and/or make the additional activity enjoyable. As discussed in Chapter 2, promisingness judgments are often directed by intuition. Shifting from intuition to reasoning runs the risk of preventing promisingness from happening at all.

Personal Epistemic Beliefs and Promisingness Judgments

It is important to note that making promisingness judgments covers important areas of epistemic cognition (Chinn, Buckland, & Samarapungavan, 2011), which requires sophis-
ticated epistemic agency in students, with results in epistemic commitment. Pedagogical supports designed for Study 2 might fall short in supporting students’ epistemic growth when engaging them in PJ.

This challenge points to an interesting research question: What is the underlying relationship between promisingness judgments and one’s epistemic beliefs (Hofer & Pintrich, 1997)? This question guided me to think what additional supports could be designed to support students’ epistemic growth, which might in turn boost students’ capability in making promisingness judgments. I turn to this matter in the next chapter.

5.5 Chapter Summary

In this study, I designed and implemented the first pedagogical intervention for PJs. While this intervention involved a high level of complexity, especially for Grade 3 students, it went quite smoothly. Students’ understanding of promisingness, reflected in their notes, classroom discussion and the epistemic nature of their highlights, suggested important competencies students bring to this work as well as important educational means to raise their awareness and effective use of promising ideas. Promisingness judgments played a distinctive role in knowledge-building discourse as shown in detailed analysis of discourse at the individual, group, and community levels. Significant knowledge advancement was confirmed, by both content analysis and semantic comparisons. Future work was needed to investigate students’ individual variation in PJs, uncover possible linkages between PJs and students’ epistemic beliefs, and design more powerful technological and pedagogical supports to advance students’ capability in making promisingness judgments.
Chapter 6

Study 3: Promisingness Judgments to Facilitate Epistemic Growth

6.1 Chapter Overview

In this chapter, I discuss the third cycle of design and implementation for students’ promisingness judgments (PJs). I begin by presenting research questions extending naturally from the first two design cycles. This is followed by a review of methods and analyses and designed socio-cognitive processes. Then I discuss results of analysis and conclude with key lessons learned from this design cycle.

6.2 Research Questions

Individual variation found in the previous two studies motivated an important question: Is it possible to better prepare students for making promisingness judgments? Students’ access to a variety of conceptions of promisingness, demonstrated in Studies 1 and 2, implied underlying epistemic factors in promisingness judgments. Since epistemic aims, stances, and virtues are important aspects of epistemic cognition (Chinn et al., 2011), this raises the further question: To what extent can epistemic beliefs be accessed and
advanced by making promisingness judgments?

Lessons learned from Study 2 also suggested tool refinement to elicit students’ thoughts behind their PJs. Technological design in this area is pertinent to the investigation of epistemic beliefs because it would expose students’ epistemic cognition during promisingness judgments and thus make it accessible for analysis.

This study aimed to probe linkages between promisingness judgments and epistemic beliefs with greater pedagogical and technological supports for students. Embracing a multi-facet approach of epistemology, it attempted to inspect the possible bi-directional relation between epistemic beliefs and promisingness judgments. In particular, by employing readily available instruments for assessing epistemic beliefs, this study mainly targeted the following two questions:

1. What is the nature of the relationship between students’ current level of epistemic beliefs and their promisingness judgments?
2. Would practice in making promisingness judgments lead to changes in students’ epistemic beliefs?

In addition, by investigating effects of technological and pedagogical supports designed for PJs in a knowledge building context, this study was also interested in questions investigated in Study 2; namely,

3. Can pedagogical supports and practice serve to improve students’ knowledge of promisingness and ability of making promisingness judgments?
4. To what extent was students’ scientific understanding improved as a result of promisingness judgments?
6.3 Methods and Analyses

6.3.1 Participants

One class of twenty-six Grade 6 students from School B participated in this study. They were studying a science unit about “Population Growth” during the study. This school was a bilingual school; all students in the class could speak English fluently, and all of their science lessons were taught in English. Students were from middle-upper class families. Before this study, the teacher and students had several years of experience with Knowledge Building and Knowledge Forum. As noted earlier in Chapter 3, the school culture emphasized acquisition of content knowledge in line with curriculum standards and during the present study students were studying a science unit on “Population Growth.” The situation presented both a challenge and an opportunity for promoting PJs among students and advancing their epistemic beliefs.

The teacher of the class, who was also the biology division lead in this school, has been heavily involved in the design of the pedagogical supports for students. Teacher participation has been especially valuable for working in a school without the long knowledge building tradition of School A.

6.3.2 Co-Designing the Study

Planning for this study began three months prior to the implementation. During these three months, the teacher, Jane, and I met four times through Skype to discuss the research design. Through these meetings and additional email exchanges, I achieved a number of important goals: getting to know Jane’s class, planning to integrate her teaching more deeply with Knowledge Building, and setting PJs as a major theme in the science unit of study. Thanks to a research travel grant from the University of Toronto, I was able to travel to Colombia for one week of field work with School B. During this visit, we worked intensively together every day, implementing pedagogical supports
collaboratively, exchanging ideas from time to time, and revising plans as needed. The teacher played an essential role in this study.

**Getting to Know the Class**

Successful classroom interventions depend on deep understanding of classroom practice. The first meeting with Jane focused on familiarizing myself with her teaching and introducing her to my research goals. We discussed her course plan, authoritative resources to be used, online materials chosen, and activities designed for the unit. Although she has been teaching biology for years, it would be the first time for Jane to teach “Population Growth” and would require mathematics that might be difficult for students. Regarding her way of teaching, she usually began with definitions of key concepts and having students watch videos, explore online resources, participate in activities and games designed for these concepts, and use Knowledge Forum for discussion. She later shared her course plans and online textbooks to orient me.\(^1\) Based on Jane’s description, her teaching could be best characterized as “inquiry learning” closely aligned with curriculum standards in School B.

We also discussed how promisingness would fit in her class. In particular, because Jane had a research interest in scientific argumentation, which her master’s thesis focused on, we discussed how promisingness and argumentation might fit together. She was open to explore new approaches reflecting an important virtue of design in the teaching profession (Laurillard, 2012). As she mentioned, she had changed how she used Knowledge Forum in her class during the past few years. In addition, she mentioned that in her first trial of PI in two higher grade classes one year ago, she was disappointed that students were not selecting truly promising ideas. So she was very motivated to co-design pedagogical supports to help students tackle challenges in PJ.

\(^1\)Teachers in School B used an online system for course planning. Each teacher needed to write an overarching plan before a semester begins and have the plan approved by school administrators. The textbook used by Jane’s class was from: http://www.nexuslearning.net/books/Holt_ENV_Science/.
We also discussed logistics, including a feasible research timeline, Knowledge Forum server update, and pre-test arrangements.

**Integrating Knowledge Building More Deeply**

Recognizing the classroom paradigm was inquiry-based learning, our first design challenge was integrating Knowledge Building more deeply. In subsequent Skype meetings, we talked about the extent to which students could explore their own ideas; we also discussed the role of Knowledge Building in her teaching. In particular, we discussed her students’ use of Knowledge Forum, what students normally discuss, and how she participates in Knowledge Forum. After much discussion, we decided to treat inquiry learning and Knowledge Building as two concurrent and interactive lines of work in her class. Jane would teach students key scientific concepts and principles through inquiry learning (as described above), and engage them in exploring concepts and making connection with real-world problems through Knowledge Building. In addition, we agreed to put less weight on argumentation and emphasize continual idea development. Noticing the need to advance students’ sense of community knowledge, we decided to implement classroom interventions to help students treat Knowledge Forum as a public space where their ideas grow—rather than a discussion forum for debates—so that continual revisions of ideas could be supported all through the unit.

**Making Promisingness a Major Theme**

After ensuring Knowledge Building would play a significant part in this unit, the next goal was to co-design pedagogical configurations to recognize promisingness as a major theme in Knowledge Building. Sessions were designed accordingly, to elicit students’ prior understanding of promisingness and raise their awareness of promisingness through discourse.

A second part of the design was to let students’ promisingness judgments dictate
their discussion. We decided to adopt a multi-phase design similar to that applied in Study 2—asking students to discuss and choose the most promising ideas or challenging problems at the end of each phase as the starting point for the next phase.

We also agreed on the significance of having students reflect on the journey of PJs at the end of this unit, so that they could take a meta-perspective of their judgments and retrospectively assess the extent to which their promisingness judgments were successful. This design idea eventually took the form of a “portfolio note” written by each student at the end of the unit. By reviewing their PJs and looking back into their knowledge-building discourse, they were expected to gain additional insights from their experience of making PJs in this unit.

6.3.3 Materials

Promising Ideas Tool, Version 3

Informed by lessons learned from Study 2, the Promising Ideas (PI) tool was refined, with new components added to support student expression of thoughts surrounding selection of PJs and to provide visual cues of promisingness in Knowledge Forum. Compared to PI version 2, the new version had the following improvements.

1. Promisingness criteria. The new version of PI prompted students to express what an idea is promising for. As illustrated in Figure 6.1, when a student highlighted an idea as promising with a promisingness scheme (left side), a window appeared asking her to explain “the [highlighted idea] is [a promising idea] for understanding [what]” (right side). The criterion field was made optional, considering the additional cognitive load required. Students also had the options of typing in a criterion or choosing from a list of criteria existing in their community (available through the drop down menu). The latter choice was to help the community converge on certain knowledge areas. Because of the possibility of choosing different vocabulary to explain the same topic, providing students with existing criteria might help them identify shared interests in promising
Figure 6.1: Highlight an idea with PI version 3 in Knowledge Forum. Left side: clicking on the “Ideas” button in the note window will activate a set of highlighters to be chosen from for highlighting promising ideas. Right side: a window pops up when a highlight action is completed, and the student is prompted to provide a content-based criterion for this highlight and justify choice of the criterion.

ideas. Furthermore, the teacher could customize a list of criteria beforehand to scaffold students’ choices.

2. Promisingness reasoning. Under the promisingness criteria field, an additional text field is provided for students to explain “why the [highlighted idea] is promising for [a specific topic]” (see Figure 6.1, right side). This optional element enables students to further justify their choice of a promisingness criterion.

3. Visual cues of promising ideas. As discussed at the end of Study 2 (Chapter 5), further visual cues about where promising ideas reside in the communal knowledge space would help students self-organize themselves around promising ideas in the process of knowledge building. In the Study 2, three-phase design, directing community attention towards promising ideas relied on organized class-wide deliberation on identified ideas. To enable more continual impact of PJs on knowledge-building discourse, the new version of PI added icons to notes that contain highlights. A Knowledge Forum view with such visual cues is illustrated in Figure 6.2. As shown in this figure, a note with a bulb icon means a promising idea is highlighted within it; a question mark (i.e., “?”) denotes an
unsolved problem, and an “i” icon means useful fact being highlighted in that specific note. If multiple types of highlights are present within one note, PI prioritizes promising ideas over unsolved problems, and over accepted facts, based on the design intention of engaging students with promising ideas.

4. Filtering by criteria in the idea aggregation window. In the idea aggregation window, a new filter that allowed students to sort by criteria is provided (see Figure 6.3). Note that, as indicated above, when highlighting an idea the student had the choice of choosing a criterion predefined by the teacher or adding her own. Then through use of the criterion filter students could bring ideas under the same criterion together for review. Class-wide reflection on promisingness judgments could make use of this filter to specifically discuss emergent promising themes in their knowledge-building discourse.
5. Exporting as references and agile exporting. Compared to PI version 2, this new version further refined the export facility in two aspects. First, the entire note is not copied when a student chooses to export an idea; rather, the new version creates a new note and selected ideas are exported as references to the original notes (see Figure 6.4). In this way, PI could further facilitate sophisticated knowledge processes involving promisingness judgments, such as rising above multiple ideas to create a synthesis, resolving conflicting explanations, and linking explanations with evidence. The second improvement aims to export single ideas more agilely. In this new version, students could export an idea directly from a note window, immediately after the idea is highlighted (see Figure 6.5). This more agile way of exporting attempts to integrate promisingness judgments more deeply within knowledge-building discourse. While in older versions, exporting only happens after collective review of aggregated ideas, the new version enables users to quickly export ideas to a designated space for further inquiry.
Figure 6.4: A synthesis note created based on identified promising ideas. Promising ideas exported from the idea aggregation list are shown as references (in italic). Text surrounded by scaffolds was written by students to synthesize these exported ideas.

Figure 6.5: A note with a promising idea highlighted within. In the idea panel, three icons beside each idea allow a user to edit, export, and remove that idea. Only the highlighter of the idea can access the edit and remove facilities, while the export function is available for all community members.
Knowledge Forum Database

In this study, students used Knowledge Forum for online discussion. They created three Knowledge Forum views, including “Welcome 6A,” “Inquiry Step 2,” and “Populations.”

Domain Knowledge Test of Population Growth

To assess students’ understanding in Population Growth, a domain knowledge test that contained three multiple-choice questions and seven short answer questions was developed based on curriculum standards and online textbooks. A copy of the test can be found in Appendix B.

Epistemic Skills Instrument

As discussed in Chapter 2, there has been a long tradition of studying epistemic beliefs and their relationship to learning. The goal of this study was to explore the linkage between epistemic beliefs and promisingness judgments, as set out in instruments available in the literature to assess epistemic beliefs. The Knowledge Building team is developing an epistemic beliefs questionnaire related directly to Knowledge Building/knowledge creation (Chuy, Scardamalia, et al., 2010), but that work is at an exploratory stage and makes use of a questionnaire too lengthy for use in the current context. Thus a well-established instrument developed by Conley and colleagues (2004) was chosen (see Appendix C). This instrument contained 23 5-point Likert-scale items (1 = strongly disagree; 5 = strongly agree), focusing on the following four epistemic dimensions (Conley et al., 2004, p. 194):

- **Source** (5 items): beliefs about knowledge residing in external authorities (e.g., “Whatever the teacher says in science class is true”)
- **Certainty** (6 items): a belief in a right answer (e.g., “All questions in science have one right answer”)
• Development (6 items): beliefs about science as an evolving and changing subject (e.g., “Sometimes scientists change their minds about what is true in science”)
• Justification (9 items): concerned with the role of experiments and how individuals justify knowledge (e.g., “Good answers are based on evidence from many different experiments”)

In the instrument, the source and certainty scales were reversed (e.g., “Everybody has to believe what scientists say”), while the development and justification scales were not (e.g., “Ideas in science sometimes change”). I therefore reversed scores in the source and certainty dimensions in data analysis (explained below), so that higher scores reflected more sophisticated beliefs for all items.

Promisingness Knowledge Instrument

To probe students’ understanding of promisingness, a test containing three 5-point Likert-scale items were constructed:

1. When I first come up with an idea to explain something, being correct is the most important thing.
2. I often try to come up with my own explanations different from those in textbooks when I learn science.
3. Scientists often make mistakes, and they’re good at learning from them.

These items were developed to provide greater insight into issues raised in the conceptual framework for this thesis and the previous two research cycles. Item 1 targets the truthfulness versus potential for knowledge building idea. Item 2 probes the extent to which promisingness is tied to ideas found in authoritative sources. Item 3 explores a source of promisingness knowledge. Note that the intention was not to develop a promisingness evaluation test, but an approximate measure of promisingness understanding to be correlated with other variables.
6.3.4 Design and Procedures

The class of Grade 6 students involved in this study were, at the time of the study working on a “Population Growth” biology unit as part of a broader biodiversity topic including “Principles of Energy,” “Energy Transfer,” and “Environmental Problems.” This unit of Population Growth lasted for 10 weeks—one semester for School B’s calendar. In each week, four class sessions were dedicated to science, with each session lasting for 45 minutes.

The design and procedures of this study are illustrated in Figure 6.6. This study consisted of three phases, each of which was designed with specific components including pre-post tests, introduction to promisingness, promisingness judgments, retrospective review of promisingness judgments in the whole unit, and of course, regular knowledge-building discourse. Overall, the general structure of this study was similar to Study 2, in that promisingness judgments were discussed at the end of each phase to define the starting point of the next. So this study inherited the design intention of “letting results of PJs dictate student discourse.”

However, there were also important differences. In particular, new designs of PI afforded deeper integration of PJs in knowledge-building discourse. For instance, visual cues of highlighted promising ideas enabled the results of PJs to have a constant impact on discourse. In addition, the new exporting mechanism allowed students to create synthesis notes based on collections of highlighted ideas. Furthermore, new technological affordances were coupled with pedagogical supports to best support PJs. Detailed explanation of each component of research design is provided below.

**Pre- and post-tests:** Pre- and post-tests designed to measure changes of students’ content knowledge, epistemic beliefs, and understanding of promisingness were implemented at the beginning and the end of the study, using instruments introduced in the previous section. The pre- and post-tests administered in the form of an online question-
Figure 6.6: Procedures in the experimental class in Study 3. Note. In this illustration, the time dimension is not properly scaled.

naire delivered through LimeSurvey,\(^2\) with all participating students responding to the tests during one class session each time an instrument was presented.

**Knowledge Building:** In each phase, students contributed to knowledge-building discourse, collectively refining ideas through whole-class and small group face-to-face discussions and online in Knowledge Forum; they also read authoritative sources and conducted experiments related to population growth.

**Introduction to promisingness:** Informed by pre-test findings and insights gained from Chapter 4 and 5, the teacher and I co-designed a pedagogical intervention to advance students’ understanding of promisingness. During this intervention session, students were not directly introduced to promisingness as defined by knowledge building potential. Rather, students were engaged in discussing a series of pertinent questions: “What does a promising idea or a promising question mean?” “What is a fact?” “How is fact different from a promising idea?” etc. After this conceptual exploration, the PI tool was demonstrated to the class.

**Promisingness judgments:** After the introduction to promisingness session, students were invited to identify promising ideas in their knowledge-building work using PI. They were encouraged to do so on a regular basis throughout the unit. Special configurations in PI guided them to evaluate contributions in light of a four-level promisingness scheme, namely promising ideas, unsolved problems, useful facts, and dead-ends. Note that no time was dedicated to PJs in Phase 3—students focused on earlier judgments.

\(^2\)LimeSurvey is an open source survey application. More details can be found at its website: https://www.limesurvey.org/en/
As in Study 2, students also reflected on PJs and collectively decided on next steps accordingly at the end of Phases 1 and 2. In each phase, the class spent one session reflecting on their judgments, worked in groups to review identified ideas, and collaboratively exported to a new view ideas that they agreed represented the state-of-the-art in their community discourse. During the process, students in each group collaboratively wrote a synthesis note based on ideas they exported. A set of meta-cognitive scaffolds—including “We used to think”, “We found”, “Now we think”, and “Next we will”—were used to guide their writing. At the end of each intervention, students brought their reflection back to the whole class for discussion. The new view containing these synthesis notes was treated as the starting point of the next phase of the discourse for the class as a whole.

**Retrospective review of PJs:** This review in Phase 3 was slightly different from that in the first two phases. Assuming students had already experienced “successes” and “failures” in the course of PJs, they were asked to review not only their judgments made in Phase 3, but decisions they had made in this unit. Did ideas identified as promising earlier turn out to be fruitful? Students discussed their thoughts as a whole group and each student wrote a reflection note in Knowledge Forum.

In summary, in this study students were engaged in multi-phase, progressive knowledge building involving collective promisingness judgments supported by PI. Through more powerful tool support and more sophisticated socio-cognitive design the goal of this study was to promote deeper integration of PJs in students’ day-to-day knowledge building. Special attention was paid to helping students reflect upon identified ideas as promising and their course of development throughout the unit.

### 6.3.5 Data Sources

Data collected in this study included students’ responses to the pre- and post-tests, Knowledge Forum log files containing students’ online activities (e.g., notes written by
students and ideas highlighted with PI), and video recordings of classroom discussion. Other materials such as course plans drafted by the teacher, textbooks, and online materials used by the class were also collected to inform interpretation of data.

6.3.6 Data Analyses

Pre-Post Tests

Students’ responses to pre-post test items were scored in terms of content knowledge, epistemic beliefs, and understanding of promisingness. For the open-ended questions in the domain knowledge test, two raters scored the results and the inter-rater agreement measured by Krippendorff’s alpha was .88. As for epistemic beliefs, each response was scored according to the 5-point Likert-scale in the survey (Conley et al., 2004), with negative items reverse scored so that higher scores represented more sophisticated beliefs for all items. Students’ performance on each epistemic dimension was represented by the mean of its items. An overall score of epistemic beliefs was then computed by averaging scores across all four epistemic dimensions. Finally, students’ responses to the promisingness items (5-point Likert-scale) were scored using the same technique. Same as epistemic beliefs, higher scores represented more sophisticated understanding. The mean of three items was used as a measure of promisingness understanding.

Knowledge Forum Contributions

Students’ Knowledge Forum contributions in each of the three discourse phases were qualitatively analyzed. During each phase, students wrote notes, read and built on each other’s notes, and used PI to highlight promising ideas. An overview of notes and highlighted ideas (under all four categories) is provided in Table 6.1, and the analyses are described below.

Contribution types. As in Study 2, the contribution type of each note written by students was analyzed following a scheme adapted from Chuy et al. (2011; see Sec-
Table 6.1: An Overview of Knowledge Forum Dataset

<table>
<thead>
<tr>
<th>Phases</th>
<th>Views</th>
<th>Notes</th>
<th>Ideas highlighted with PI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>Welcome 6A</td>
<td>89</td>
<td>20</td>
</tr>
<tr>
<td>Phase 3</td>
<td>Inquiry Step 2</td>
<td>64</td>
<td>17</td>
</tr>
<tr>
<td>Phase 3</td>
<td>Populations</td>
<td>51</td>
<td>1</td>
</tr>
</tbody>
</table>

*Note. In the Populations view produced in Phase 3, no class time was dedicated to promisingness judgments. As a result, only one idea was highlighted with PI.*

Knowledge advancement. Content analysis was conducted on theorizing notes focusing on level of scientific sophistication (Zhang, Scardamalia, Lamon, et al., 2007; see Section 5.2 for details of the scheme). In the first session I found students holding a passive conception of question-answer processes, thus I examined students’ questioning and justification dynamics. So I also evaluated the depth of questioning and ways of justification in each phase (Hmelo-Silver, Chernobilsky, & Jordan, 2008) to provide additional measures of knowledge advancement. Toward this end, I coded whether students asked for factual information or detailed explanations and whether students justified their ideas based on personal beliefs or empirically/theoretically grounded beliefs, expecting more sophisticated accounts with the latter. Details of these two coding schemes are presented in Table 6.2.

Agreement with rating by adults. The third analysis focused on assessing students’ promisingness judgments based on their agreement with rating by adults with more subject-matter knowledge. Ideas highlighted under the category of “promising ideas” were analyzed according to the following three aspects: (1) promisingness of an idea—how promising is the idea within its knowledge building context from the perspective of a knowledgeable adult; (2) promisingness criterion (i.e., “promising for understanding what”)—the extent to which there is a close fit between the criterion identified by the student and the selected idea; and (3) justification—how well did a student justify the choice of a promisingness criterion. Additionally, ideas highlighted under all four cate-
### Table 6.2: Coding Categories of Depth of Questioning and Ways of Justification

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Category</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questioning</td>
<td>Factual</td>
<td>How many people are average borned by day?</td>
</tr>
<tr>
<td></td>
<td>Explanatory</td>
<td>This is so interesting! I need to understand: What factors may help these queen ants live so long and have so many babies?</td>
</tr>
<tr>
<td>Justifications</td>
<td>Personal beliefs</td>
<td>[My Theory]: I think that the overpopulation is a huge problem, but many of people don’t care about it.</td>
</tr>
<tr>
<td></td>
<td>Grounded beliefs</td>
<td>I think your theory is okay, if we go [beyond] the carrying capacity it will cause many problems.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Because if we keep reproducing we will need more resources, because there will be more individuals and we will have limiting factors and we will star dying because we will need resources for survive.</td>
</tr>
</tbody>
</table>

*Note.* Categories were adapted from Hmelo-Silver, Chernobilsky, and Jordan (2008). Examples are from the present study.

gories were evaluated in terms of (4) judgment of idea type—that is, for each highlighted idea, how well did the student make choices among four different idea types (i.e., promising idea, unsolved problem, useful fact and dead-end). These four aspects were rated on a 3-point scale. Detailed explanation and examples are provided in Table 6.3.

Two independent raters coded all Knowledge Forum notes and ideas and their agreement measured by joint agreement was .82.

**Evolution of Students’ Conception of Promisingness**

In addition, videos of classroom discussion were transcribed and analyzed to track the change of students’ conception of promisingness. Students’ final reflection notes regarding the course of their work with promising ideas was also analyzed. They together provided qualitative accounts of students’ understanding of promisingness.
Table 6.3: Coding Schemes for Promisingness Judgments

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Level</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promisingness of Idea</td>
<td>1–Already widely discussed</td>
<td>“How many babies can have a Chinese family?”</td>
</tr>
<tr>
<td></td>
<td>2–Worth exploring but not likely to lead to fruitful directions</td>
<td>“How can we get a more exactly answer of the population in a place?”</td>
</tr>
<tr>
<td></td>
<td>3–Leading to fruitful directions and possible breakthroughs</td>
<td>“Overpopulation affects many things, like in: economy, environment and politics.”</td>
</tr>
<tr>
<td>Choice of Criterion</td>
<td>1–Irrelevant or none criterion</td>
<td>Criterion—“How populations increase or decrease” for idea—“How many babies can have a Chinese family?”</td>
</tr>
<tr>
<td></td>
<td>2–Relevant direction, but too general</td>
<td>Criterion—“Overpopulation” for idea—“But the thing is not really about space. The bad side of overpopulation are the resources, they can get extinct in any moments because the human are using it in a disgusting way!”</td>
</tr>
<tr>
<td></td>
<td>3–Specific and relevant</td>
<td>Criterion—“Population Balance” for idea—“Usually, organisms try to maintain a balance between reproduction and death.”</td>
</tr>
<tr>
<td>Justification of Criterion</td>
<td>1–No or unclear reasoning</td>
<td>Justify criterion—“How populations of different species interact” for idea—“Why animals have different reproductive potential?” by saying “They need to reproduce because they need to live”</td>
</tr>
<tr>
<td></td>
<td>2–Only mentioning relevant concepts</td>
<td>Justify criterion—“How overpopulation happens” for idea—“The base of this problem is indeed the lack of education of the worldwide population.” by saying “All overpopulation problems are based on this idea: people don’t receive education of this topic”</td>
</tr>
<tr>
<td></td>
<td>3–Clear and thorough reasoning</td>
<td>Justify criterion—“Ways to prevent overpopulation” for idea—“Education is needed to reduce the number of births per day. Eventually, human population will return to its normal carrying capacity, so resources will not finish.” by saying “It tells us a potential way to prevent this problem.”</td>
</tr>
<tr>
<td>Judgment of Idea Type</td>
<td>1–Not relevant at all</td>
<td>“Is there more population in Africa or in South America?&quot; highlighted as “Promising idea”</td>
</tr>
<tr>
<td></td>
<td>2–Relevant from a specific aspect</td>
<td>“Organisms must maintain a balance between reproduction and death and, therefore, if a species lives longer, it must have few babies.” highlighted as “Useful fact”</td>
</tr>
<tr>
<td></td>
<td>3–Fits well naturally</td>
<td>“The increase of people will cause a depletion of resources and a increase of CO2 and diseases” highlighted as “Promising idea”</td>
</tr>
</tbody>
</table>
6.4 Results

6.4.1 Enactment of Pedagogical Supports

The three-phase design resulted in three promisingness judgment sessions in the study, with different design and goals. I had the chance to physically attend the first two sessions during my visit to School B, and had access to videos of the last session recorded by the teacher. An account of classroom activities during these sessions is provided as a way to assess enactment of pedagogical supports for PJs.

Introduction to Promisingness

The first promisingness judgment session was implemented in Week 2 of this unit, on the first day of my visit to School B. My role in the class was a co-teacher, leading conversations with Jane, demonstrating PI to students, and providing technical supports as needed.

The main goal of this session was to elicit students’ intuitive understanding of promisingness and advance it through discussing related questions designed based on my understanding of their Knowledge Building practice. These questions included:

- What is going to happen to questions posted in Knowledge Forum?
- What do you mean by an answer is good or bad?
- What does a promising idea or a promising question mean to you?
- Are all promising ideas correct?
- What is a fact?
- How is fact different from a promising idea?
- How will you define a promising idea now?

Discussion of the first few questions uncovered students’ naive understanding of knowledge building and promisingness. First of all, being asked about what to do with ques-
tions, student responses overwhelmingly focused on “answering” them, without mentioning any of the more advanced aspects such as analyzing, problematizing, and operationalizing a question. For example, one student said “if it’s too difficult, no one is going to answer it.” Another student said, “if the question is going to be answered, it will be discussed by our group.” Another student raised the issue that “some questions are impossible to be answered.” The overwhelming emphasis on answering exposed an issue explored by Dillon (1982): “The dynamics of a question-answer relationship establish respondents in a passive, reactive role, fostering dependency and removing a sense of responsibility, initiative, and a kind of energy” (p. 160). Thus, at the beginning students showed a shallow understanding of questioning in inquiry learning.³

The teacher and I followed up by asking “what to do next after someone provides an answer.” The class was quiet for a while, then a boy said, “If the answer is good, we say ‘thank you.’ If the answer is bad...” While this response still reflected a focus on the “question-answer” dynamics, it tapped into the issue of comparing different answers or ideas. The teacher and I realized it might be a good moment to lead students to ponder upon promisingness. So the teacher asked,

Are our answers really good or bad? What do you think if an answer can be really good or bad?

And I added,

What do you mean by good or bad? How do you make this judgment? Why this answer is good, and why this is bad?

Afterwards, the discussion exploded. Not surprisingly, students’ first responses focused on the quality of answers, especially in terms of “correctness.” For example, as one student said, “a good answer is precise and accurate.” At the same time, some other students raised the issues that sometimes “one question can have multiple answers” and “judging whether one answer is good or bad depends on one’s personal opinion.”

³The use of vocabulary is crucial. In this class, the word “answer” was more often mentioned than “idea” and “explanation.” This might be related to the fact that English was students’ second language. However, it still reflected the norm of their regular classroom practice.
Recognizing students were gradually venturing into theoretical discussion charged with epistemic beliefs, the teacher asked students to ponder on the question “how many times are the answers in Knowledge Forum completely precise or accurate when appearing for the first time?” One boy immediately said “it’s not possible.” Students realized arriving at a complete explanation took time. As a girl explained, “When we ask a question ... then we go forward, we ask what we think or we Google it. To get a very complete or accurate answer, we need more investigation.” Another girl added, “That’s very difficult, because as you said, we need more information to get to a very precise and accurate answer. And that needs trying and trying till the answer is complete.” Although using Google may not be the ultimate way of dealing with questions, these explanations went further than the initial more passive account of question-answer dynamics. Students became increasingly aware that tackling a question usually required long-stretches of work. And I realized that the discussion arrived at a point to introduce the concept of “promising ideas.” So I asked:

That’s great. A lot of researchers, including me, are thinking about a concept called promising idea. Do you know, what does ‘promising’ mean? [Some students shaking heads, and the teacher explained the vocabulary before I continued.] Actually when scientists come up with some ideas about an answer, they are trying to figure out whether this idea is promising or not—more promising or less promising than other ones. Similar to what you were talking about—whether this idea is good or bad. They were thinking about the same thing. And people around the world have not really figured out how scientists make this decision and this judgment. Today, a group of researchers are trying to understand how people like you, Grade 6 students, how you guys make this decision. And we are going to connect what you are thinking with what scientists are thinking about promising ideas. So I want you guys first to think about what does promising mean, what does a promising idea or a promising question mean to you?

After making sure students understood the vocabulary “promising” and its Spanish equivalent, students worked in small groups to discuss this concept and record their thoughts on paper. They then gathered and explored issues of the sort tackled in Study 2 with teacher guidance. These issues included “whether promising ideas are all right.”
“what is a fact,” and “what we are going to do about identified promising ideas.” Details of their understanding of promisingness will be presented in the next section. Overall, the first pedagogical interactions were productive in terms of helping students think beyond “correctness” and recognize “promisingness” as a facet of idea improvement. As I wrote in my field notes after this session,

The intervention followed the plan quite closely. Students had a lot of opportunities to think and explain themselves. Some kids were more dominant than others. But overall kids could get their thoughts written down on their group worksheet and speak out later. Not surprisingly, kids firstly tied the concept of promisingness to being correct or true. They seemed to be accustomed to a quite traditional thinking of school work—expecting to get to the right answers, probably from the authorities such as teachers or books sometimes. However, some kids quickly got it. As they move along in the discussion, they got into some deeper issues related to promisingness, such as epistemological issues like whether there is a correct answer to a question and whether an idea that is thought to be true many years ago can be falsified later. Sometimes, kids got deep into specific questions related to their work in populations.

**Continual Supports for Student Promisingness Judgments**

The first session did not leave enough time for PI demonstration or promisingness judgments, which were then carried on in the second session. At the beginning of the second session, the teacher recapitulated the discussion in the first session. I then demonstrated PI for approximately 10 minutes, and students were ready to make promisingness judgments in Knowledge Forum on their own. During the process, Jane, Finn, and I walked around the classroom to provide technical support. Students did not review their highlights or export them to a new view in this session.

From conversations with individual students the teacher realized some students were still thinking of promising ideas solely in terms of “correct ideas.” She raised the concern to me that there was no final definition given to the students in this class. I conveyed that understanding would be sharpened in the process of using the tool, and refinement through use and feedback is arguably the best way to come to a better understanding of
knowledge building potential. We agreed that in the third session we would revisit this matter.

In the later part of the third session students spent 10 minutes making PJs and writing notes unfinished in the previous session. Afterward they were organized in small groups to review identified promising ideas, select those under a topic they were interested in, and export them to a new view. After exporting to the new view, each group wrote a rise-above note based on these ideas—referenced in the note—using the synthesis scaffolds (i.e., “We used to think,” “We found,” “Now we think,” and “We will”).

In summary, in the first phase of this study, the teacher and I spent a considerable time across multiple sessions discussing with students their understanding of promisingness. The concept was indeed challenging for these students who seemed fixed on a question-answer, fact-based account of inquiry and promisingness.

In the promisingness judgments intervention at the end of Phase 2 (see Figure 6.6), the class had another substantial discussion of promisingness. In this discussion, we invite students to reflect on the change of their thoughts regarding promisingness. Student discussion reflected a growth trajectory. For example, one student said,

I thought what makes ideas promising is it is true. But later I realized more importantly it should produce interests of further investigation or discussion.

Students were further asked to provide examples of ideas in their Knowledge Forum discussion that were promising or unpromising. A few students got the chance to share. Some of them were able to find seemingly promising ideas, such as “we should investigate the link between marriage and overpopulation” and “how is overpopulation related to economy, environment, and politics.” When a boy reported “Most Colombian people are poor” as a promising idea, the teacher further asked why he thought it was promising; then he clarified by saying that “poor people don’t have access to education. So they don’t have the concept of overpopulation.” The teacher took the chance to stress the
point that a piece of fact may not be promising itself but could be framed in a way to produce a promising idea.

To summarize, after the first phase of PJs, continual efforts were made to support students in a knowledge-building potential conceptualization of promisingness. Individual differences among students were evident, as some students showed clear growth while others did not depart from seeing promisingness exclusively in terms of truthfulness. As these findings indicated, achieving a favorable understanding of promisingness was not an easy task for students accustomed to inquiry learning, without a knowledge building orientation to idea improvement. However, the enactment of pedagogical supports for promisingness judgments demonstrated the possibility of considerably advancing students’ understanding of promisingness by engaging them in meaningful conversations about relevant concepts. In the third session the teacher recapped the concept of promising ideas as knowledge building potential. Some students still showed a distinct preference for a truth-based account of promisingness.

### 6.4.2 Evolution of Students’ Knowledge of Promisingness

According to Bereiter (2002a), the knowledge of promisingness accumulates from experiences of successes and failures of PJs during creative processes. One important research question I have been investigating all through this dissertation was whether students’ knowledge of promisingness could be improved over the course of interventions. In this study, analysis of classroom dialogues and students’ reflection notes did reveal a gradual shift in their conception of promisingness. A summary of the shift is presented in Table 6.4.

In the early stage of the intervention, students’ intuitive understanding of promisingness overwhelmingly centered on truthfulness. This focus was later challenged by a relativist point of view introduced by a few students, despite a continued concern with truthfulness. As the discussion went on, the relativist point of view further led students
Table 6.4: Facets of Student Conceptions of Promisingness

<table>
<thead>
<tr>
<th>Facets</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute truthfulness</td>
<td>“A promising answer is something that convinces you and is a good answer, and we prove that the answer is perfect.”</td>
</tr>
<tr>
<td></td>
<td>“It is true. You have the observation that is true.”</td>
</tr>
<tr>
<td>Relative truthfulness</td>
<td>“It is impossible to locate the most promising answer because people have different points of view.”</td>
</tr>
<tr>
<td></td>
<td>“It depends on the person who writes the idea.”</td>
</tr>
<tr>
<td></td>
<td>“Other thing is like the point of view you have. If we are educated that way, we will think it’s promising.”</td>
</tr>
<tr>
<td>Probabilistic truthfulness</td>
<td>“We think promising idea is like a possible answer. It probably can be correct.”</td>
</tr>
<tr>
<td></td>
<td>“We don’t think promising means absolutely correct but near correct.”</td>
</tr>
<tr>
<td></td>
<td>“A promising answer is one that is closer to the absolutely correct answer, since there is no absolutely correct answer.”</td>
</tr>
<tr>
<td>Knowledge building potential</td>
<td>“I think that’s not necessary an expert can make a promising answer ... Because the promising question takes time, not like a question you [can do] in a second.”</td>
</tr>
<tr>
<td></td>
<td>“At the beginning I thought it was the correct answer, but now I think it’s not ... So it’s an idea that can be discussed to get to ...”</td>
</tr>
<tr>
<td></td>
<td>“A promising idea is something has a lot of ‘searching’...”</td>
</tr>
<tr>
<td></td>
<td>“I think what makes ideas promising is ... it produces interests of further investigation or discussion.”</td>
</tr>
<tr>
<td></td>
<td>“A promising idea is not the answer; it is the idea that leads you to discussion. As we said before, they are not necessarily the correct answer, but those topics can lead you to discuss and be engaged, and learn a little bit about that topic.”</td>
</tr>
</tbody>
</table>
to the notion of “possibility”—that a promising idea is not necessarily true, but might ultimately lead to some true ideas. Then student conceptions became further elaborated in later discussion. For instance, some students came to realize that promisingness judgments served to identify areas that were worth investing time on. In these examples presented in Table 6.4, it appeared that students’ understanding of promisingness was constrained by their vocabulary. However, analysis clearly indicated that most of them had made progress over their earliest understanding. These findings show that through pedagogical support and practice in knowledge-building dialogues students can operate successfully on the basis of a knowledge building potential account of promisingness.

I further analyzed students’ PJs in knowledge-building discourse to investigate their in-vivo understanding of promisingness. As described in the methods section, this analysis focused on rating in four aspects: (1) the promisingness of selected “promising” ideas, (2) judgments of idea type, (3) promisingness criterion, and (4) justification for the chosen criterion. Because only one idea was highlighted in Phase 3, only the first two phases were compared. As indicated in Table 6.5, the means of these measures increased from Phase 1 to Phase 2. However, further $t$-tests only confirmed a significant improvement in the justification aspect, $t(31) = -3.52, p < .01$. Additional inspection on means found students’ performance on judging idea types already quite high in Phase 1 ($M = 2.50, SD = 0.83$), leaving little space to improve in Phase 2 ($M = 2.70, SD = 0.47$). For the other two aspects, i.e., idea promisingness and judgment of criterion, great variance was found among students, implying substantial individual differences on those two dimensions. Overall, analysis of students’ promisingness judgments indicated that even though their conception of promisingness had shifted over the course of the intervention, their actual performance in most important aspect of promisingness judgments had not significantly changed. Because knowledge of promisingness is acquired from rich experience (Bereiter, 2002a), perhaps it required more time and more contextually meaningful opportunities in order for students to achieve significant improvement in their actually judgments.
<table>
<thead>
<tr>
<th>Phases</th>
<th>Promisingness</th>
<th>Categorization</th>
<th>Criterion</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>M 2.00</td>
<td>2.50</td>
<td>2.10</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td>SD 0.67</td>
<td>0.83</td>
<td>0.91</td>
<td>0.67</td>
</tr>
<tr>
<td>Phase 2</td>
<td>M 2.12</td>
<td>2.7</td>
<td>2.41</td>
<td>2.24</td>
</tr>
<tr>
<td></td>
<td>SD 0.78</td>
<td>0.47</td>
<td>0.87</td>
<td>0.83</td>
</tr>
</tbody>
</table>

### 6.4.3 Inspecting Knowledge Advancement

#### Domain Knowledge Test

A pre-post domain knowledge test was designed to assess students’ understanding of “Population Growth” according to curriculum guidelines for the biology unit they were studying, the textbook they were using, and course plans made by the teacher. A paired samples \( t \)-test was conducted to assess the change of students’ conceptual understanding during this study. Results indicated a significant improvement, \( t(24) = -5.75, p < .001 \). The average score was improved from \( M = 5.44 (SD = 1.74) \) to \( M = 8.46 (SD = 3.16) \).

#### Level of Scientific Sophistication

The level of scientific sophistication was coded for any Knowledge Forum note that contained a theorizing contribution, with mean scores of scientific sophistication compared between Phase 1 and Phase 2 using a two-sampled \( t \)-test. Phase 3 was left out in this comparison because of its limited number of conceptual contributions. Results indicated that scientific sophistication of notes had improved significantly from Phase 1 to 2, \( t(44) = -2.02, p < .05 \). Notes moved from a hybrid level of scientific sophistication \( (M = 2.12, SD = 0.85) \) to a level closer to pre-scientific \( (M = 2.65, SD = 0.93) \).
Depth of Questions and Justification

To find out whether students’ questions and explanations were also deepened across three phases, depth of questions and justifications of students’ theoretical ideas (i.e., ideas containing theorizing contributions) were examined. For the depth of questioning, a chi-square test of independence found a marginally significant difference across three phases, $\chi^2(2) = 5.50$, $p = .06$. Further descriptive analysis found the number of factual questions declined from 16 out of 31 in Phase 1 to 1 out of 8 in Phase 2, and to none in Phase 3. This pattern could be clearly observed from the Chronologically-Ordered Representations of Discourse and Tool-Related Activity (CORDTRA) diagram (Hmelo-Silver, 2003; Hmelo-Silver, Chernobilsky, & Jordan, 2008) presented in Figure 6.7.

![CORDTRA visualization of content analysis results.](image)

Figure 6.7: CORDTRA visualization of content analysis results. Two coding schemes—“Ways of Contributing” and “Depth of Problems”—are presented. Each line represents one category of coding, with one dot denoting its appearance in a note. The horizontal line represents discourse units (or notes) sorted in chronological order, with later discourse units on the right. The two vertical dash lines separate three discourse phases, which had 89, 64, and 51 discourse units respectively.

Meanwhile, analysis of justification of theories did not confirm a significant improvement across three phases, $\chi^2(2) = 4.62$, $p = .10$. However, the count of theories that
were grounded on evidence increased from 4 out of 24 in Phase 1 to 7 out of 23 in the second phase.

Overall, these outcomes suggested increasingly deep questioning and sophisticated justification of ideas across the phases. However, in the absence of a comparison group, these changes may not be directly attributed to promisingness judgments.

6.4.4 Did Epistemic Beliefs Have a Possible Impact on Quality of Promisingness Judgments?

Before any attempt to answer this question, I first tested the consistency of the instrument for epistemic beliefs (Conley et al., 2004) using confirmatory factor analysis (CFA). Test of four-dimension hypothesis in CFA was sufficient, with $\chi^2(227) = 307.6$, $p < .001$, and a goodness-of-fit score of 0.94. Detailed inspection on the loading matrix found four identified components properly loaded on related questionnaire items, as expected. Thus, data of epistemic beliefs collected in this study fitted the measurement model in the applied instrument.

To inspect whether students’ promisingness judgments were possibly affected by their epistemic beliefs, correlation analysis was conducted between students’ pre-test scores of epistemic beliefs and their promisingness judgment performance measured by quality rating. Results showed no significant correlation between them. This finding might be due to the fact that the pre-test of students’ epistemic beliefs was administrated before the first classroom intervention whereas promisingness judgments took place after the intervention; perhaps students’ epistemic beliefs were revised during the intervention. In this case, I inspected the correlation between students’ epistemic beliefs and promisingness understanding both measured in the pre-test. Correlation analysis indicated promisingness understanding was weakly, but significantly, correlated with three dimensions of epistemic beliefs, including certainty of knowledge ($r = .23$, $p < 0.05$), development of knowledge ($r = .33$, $p < 0.01$), and justification of knowledge ($r = .38$, $p < 0.01$). Correlation with
the other dimension, source of knowledge was nonsignificant \((r = .08, \text{n.s.})\). Note that higher scores in all scales represented more sophisticated beliefs/understanding, these results indicated that students’ prior understanding of promisingness and their epistemic beliefs were seemingly positively related, despite the lack of evidence for the impact of epistemic beliefs on students’ promisingness judgments.

### 6.4.5 Changes in Students’ Epistemic Beliefs

To investigate changes of students’ epistemic beliefs between pre- and post-test, paired-sample \(t\)-tests were conducted on the overall score of epistemic beliefs as well as scores on the four epistemic dimensions. Results indicated that students’ scores had significantly improved in their overall epistemic beliefs \((t(24) = -3.80, p < .001)\), as well as individual dimensions including source of knowledge \((t(24) = -2.61, p < .05)\) and justification of knowledge \((t(24) = -2.96, p < .01)\). The improvement on the other two epistemic dimensions—certainty of knowledge \((t(24) = -1.86, p = .08)\) and development of knowledge \((t(24) = -1.72, p = .10)\)—was marginally significant. Note that higher scores in all scales represented more sophisticated beliefs, students demonstrated growth in epistemic beliefs in the study.

Further inspection of mean scores found students’ epistemic beliefs in the source and certainty dimensions less developed compared to the other two dimensions (see Figure 6.8). This could be related to the specific school culture emphasizing acquisition of knowledge from authoritative sources rather than Knowledge Building/knowledge creation. While students could well understand science as an evolving and changing subject and the idea that knowledge needs to be justified, they tended to believe in the existence of right answers and external authorities as the source of knowledge. This finding fits with an earlier account of students’ holding what Dillon (1982) refers to as a passive stance towards inquiry—a question-answer account of the process. The pattern of improvement in these dimensions indicated productivity in advancing students’ epistemic
beliefs regarding promisingness and Knowledge Building.

Since the certainty dimension was only marginally improved, I further investigated its change in this study. Recognizing gender as an important factor for epistemic beliefs (e.g. Perry, 1970), I further conducted a two-factor analysis of variance (ANOVA) of the certainty dimension on trial (Pre- vs. Post-test) and gender (Female vs. Male). Results showed that gender was the only significant main factor ($F(1, 48) = 9.41, p < .01$), with girls having more sophisticated epistemic beliefs in certainty of knowledge. However, post-hoc comparisons among four groups indicated that girls did not improve much on this dimension (from 3.52 to 3.54), while boys were catching up (from 3.00 to 3.44) during this study (see Figure 6.9). This finding implied an interesting benefit of the promisingness intervention in advancing boys' epistemic beliefs. Analysis of classroom discussion triangulated this finding, as girls first proposed “relative” and “probabilistic” truthfulness in the intervention.

In order to identify possible contributing factors for the change of epistemic beliefs, correlation analysis was conducted among various measures, including promisingness
conception, conceptual understanding, and their changes from pre- to post-test. Results indicated overall epistemic growth (i.e., the change of epistemic beliefs) was significantly correlated with the change of promisingness conception ($r = .47$, $p < .05$) and the change of conceptual understanding ($r = .46$, $p < .01$). In addition, promisingness conception and conceptual understanding were also found significantly correlated ($r = .52$, $p < .01$).

In summary, results implied a possibly positive impact of promisingness judgments on students’ epistemic growth, especially on the dimensions of source of knowledge and justification of knowledge. Promisingness judgments may have also helped boys catch up in the certainty of knowledge dimension, an area of epistemic beliefs where gender has been found to play a role. Finally, preliminary correlation analysis found epistemic beliefs developed in tandem with domain knowledge and understanding of promisingness; in other words, changes in epistemic beliefs were found positively correlated with changes in promisingness understanding and domain knowledge.
6.5 Discussion

6.5.1 Major Research Findings

This study engaged a class of sixth grade students in making promisingness judgments about their own community’s ideas. An important research goal was to explore the relation between PJs and epistemic beliefs. Results indicated students’ prior understanding of promisingness was significantly correlated with three dimensions of epistemic beliefs, including certainty of knowledge, development of knowledge, and justification of knowledge. By comparing students’ pre-post test scores in epistemic beliefs, I also found students’ overall epistemic beliefs significantly improved during this study, as well as in the two specific dimensions of source of knowledge and justification of knowledge. This improvement was especially significant for boys in the dimension of certainty, revealing additional benefits of this intervention. Further correlation analysis found students’ epistemic beliefs developed along with their conception of promisingness. Therefore, this study opens up possibilities of further investigation regarding the effectiveness of promisingness judgments in facilitating students’ epistemic beliefs and the possibility of being better prepared for PJs.

Detailed analysis of classroom activities indicated that focus on inquiry learning in their previous classroom practices led to a primarily fact-based, question-answer account of inquiry rather than a knowledge building promisingness approach in which promising ideas propel inquiry beyond early answers to increasingly deep and profound discoveries. Results suggest that the pedagogical interventions used in this study shifted them somewhat to a knowledge building approach. This shift began with invitation for students to discuss among themselves the concept of promisingness. They then spent time making promisingness judgments, justifying them, discussing selections and rationale, and refining subsequent activity based on promising idea selections. There is suggestion that improvement in knowledge building was evident as the work proceeded across the
three phases of the study. There was improvement of scientific sophistication and depth of questioning across discourse phases, as well as anticipated improvement in conceptual understanding reflected in increases in domain knowledge from pre- to post-test. Growth in domain knowledge was found correlated with development of promisingness knowledge and epistemic beliefs. Of course, the absence of a control group represents a serious problem in interpreting results. It could be argued that these improvements in domain knowledge and epistemic beliefs did not result from engagement with promisingness judgments at all, but might well be found in any comparable classroom.

6.5.2 Limitations of Study 3

This study is best viewed as an exploratory effort to relate promisingness judgments and epistemic growth. As indicated above, it had serious limitations—most significantly the lack of a control group, so it could be argued that improvements in domain knowledge and epistemic beliefs did not result from engagement with promisingness judgments. It should be noted, however, with respect to epistemic beliefs, that students entered into this work experienced with inquiry learning within the framework of curriculum guidelines implemented in School B. This general framework was seemingly a factor in their holding a fact-based account of promisingness. Thus a subsequent shift suggested results attributable to new procedures. It is harder to make this argument for advances in domain knowledge, as engagement of any sort with new content would likely lead to advances. Clearly, much more intensive work involving control groups will be necessary to sort out these issues.

The second limitation of this study was its small sample size. This class only had twenty-six students. Because they were working in small groups, only half of them were traceable in logs of the Promising Ideas tool. This limitation hampers statistical analysis, especially the correlation analyses in which cases were removed because of empty values in different sources. Since this study was exploratory, future research with stricter design
and larger sample sizes is expected to deepen this research of PJs and epistemic beliefs.

6.6 Chapter Summary

This chapter further advances the line of promisingness judgments research initiated in this thesis by enriching functionalities of PI, extending PJs research to a new school context, and exploring the linkage between promisingness and epistemic beliefs. Results follow the pattern in previous chapters, again confirming that students’ understanding of promisingness could be advanced through pedagogical supports and practice making and evaluating PJs. Interesting linkages between PJs and epistemic beliefs have been uncovered, opening up new possibilities for future research.
Chapter 7

General Discussion

7.1 Chapter Overview

Three cycles of technological and pedagogical designs were implemented to support promisingness judgments (PJs) by elementary school students, and to determine the extent to which these judgments could help advance their knowledge-building discourse. This project was situated in a larger, international effort to seek ways to make knowledge-building discourse a sustaining force for communities committed to knowledge advancement. The outcomes of this effort include a Promising Ideas tool fully integrated within Knowledge Forum, documented socio-cognitive processes to engage students in promisingness judgments, critical findings on children’s ability to evaluate promisingness of their community ideas, and positive effects of this practice on their knowledge building. The first study was exploratory, probing students’ responses to the concept of promisingness and seeking possible socio-cognitive configurations to engage students in making promisingness judgments. The second study was more ambitious and substantive, implementing the first pedagogical intervention for PJs and investigating the integration of PJs within knowledge-building discourse at multiple levels. The third study was exploratory again, experimenting with improved design of the tool and tapping into the connection between
PJs and epistemic beliefs. In this chapter I discuss findings in regard to the five major research questions presented in Chapter 2, as well as some broader implications of this study for knowledge building research. Finally, I discuss future directions for research on promisingness judgments and knowledge building.

7.2 Addressing the Research Questions

Although the concept of promisingness has been elaborated two decades ago (Bereiter & Scardamalia, 1993), it has never been raised as an issue in any form of education. For many contemporary educational approaches, there is no need to invite students to evaluate the promisingness of their ideas and make decisions on their own, because students’ own ideas play only an incidental role in the approach. People might ask why promisingness matters for education or “what is promisingness anyway.”

Knowledge Building provides a context in which promisingness matters. As a distinctive educational approach, Knowledge Building treats “the production and continual improvement of new knowledge” as the leading goal, while learning becomes subordinate to creation and happens naturally during knowledge creation (Scardamalia & Bereiter, 2003). Knowledge Building puts ideas at the center of education and guides students to continually improve them through communal discourse (Scardamalia & Bereiter, 2006), and thus brings education into closer alignment with knowledge practices in the knowledge age, in which knowledge production has never been so crucial in human history (Drucker, 1994). In this context, promisingness becomes highly relevant, to an extent that whether a conceptual breakthrough can be achieved greatly depends on whether promisingness of present ideas can be accurately judged. When applied to concept development, the concept of promisingness can be meaningfully explored in a knowledge building context. With the concept of promisingness thus situated, in this section I discuss research questions that guided this dissertation, outcomes of studies conducted, and
implications for knowledge building and broader learning sciences research.

**Question 1: Do Young Students Have Awareness of Promisingness of Their Own Ideas? What Are Their Intuitive Perceptions of the Concept of Promisingness?**

The question whether young students can have any understanding of promisingness served as a starting point for further investigation of PJs. Attempts to address the question were evident in all three studies or design cycles.

In Study 1, Grade 5/6 students, in the absence of any explicit effort to explore this concept, were found to confuse promisingness with truthfulness. When they were asked to identify promising ideas, they highlighted a substantial amount of important-sounding facts of the sorts they deal with in school curricula. However, further exploration of intentionally designed socio-cognitive processes found this issue addressable by situating promisingness in a meaningful knowledge building context. This pointed to possibilities of pedagogical design to foster students’ understanding of promisingness.

In Study 2, which moved down two grade levels, Grade 3 students were found having the same issue as their older peers. In particular, when asked about the meaning of a promising idea, many students linked it with truthfulness. Fortunately, however, from analysis of classroom discussion it was found students’ conception had certain facets—high-probability of being correct and knowledge building potential—that were important constructs of the promisingness concept and thus conducive to more advanced understanding of this concept.

In Study 3, when I moved to Grade 6 in a school with a less strong Knowledge Building tradition, students were also found having trouble distinguishing promisingness from truthfulness and other traditionally recognized qualities of ideas such as “completeness.” By tracking the progression of promisingness knowledge during the pedagogical intervention, it became apparent that their understanding had gone through interesting changes,
from linking promisingness with *absolute truthfulness*, to *relative and probabilistic truthfulness*, and then to *inspiring future actions* or *knowledge building potential*.

These similar trajectories identified in different studies revealed important hurdles young students normally encounter when working with promisingness. They also highlighted building blocks of pedagogical supports to promote students’ knowledge of promisingness.

**Question 2: How Can We Raise Students’ Awareness of Promisingness and Support Them in Making Promisingness Judgments in Their Knowledge Building?**

In this dissertation study, each design cycle presented different supports to help students make better promisingness judgments. Some supports worked and others failed. To summarize, fruitful design principles included:

1. Elicit students’ prior understanding of promisingness and advance them with dialogues and meaningful examples
2. Ensure promisingness judgments are made for the sake of knowledge advancement, by making PJs impactful for knowledge-building discourse
3. Treat promisingness judgments as a community effort rather than an individual competition so that students feel safe about having their ideas evaluated and evaluating peers’ ideas
4. Make students’ thinking behind PJs visible so that associated beliefs, stances, and virtues become apparent and ready to be advanced

While these design principles may sound vague, in each study I presented detailed description of related knowledge practices. For example, principle 1 was present in all three studies, principle 2 was incorporated in Study 2 and 3 (see Section 5.3.1 and 6.4.1), and principle 4 was only implemented in Study 3 (see Section 6.4.1).
Moreover, one thing I wish to clarify is that these principles of supporting promisingness judgments do not translate to specific instructional procedures. Rather than “instructing” students in the concept of promisingness, I aimed to help them grow into a culture or a mindset of evaluating promisingness of their ideas when tackling creative knowledge goals. The designed pedagogical supports served as scaffolds to elicit their conceptions, explore misconceptions they might hold, and create a favorable context for their work. Thus pedagogical supports were guided by principles that were dynamic and flexible enough to accommodate new issues as they emerged. In these studies, teachers had been always alert to responses from students and followed up with additional supports during promisingness interventions. Hence, while this study identified a few key principles for advancing students’ promisingness knowledge, when they are applied in practice it is key to remain responsive to new, emergent needs in a specific context.

**Question 3: How Would Promisingness Judgments Influence Knowledge-Building Discourse, at Both Individual and Community Levels?**

In knowledge building, the evaluation of promisingness is treated as an integral component of its discourse model. In his keynote at the 2010 Knowledge Building Summer Institute in Toronto, Bereiter (2010) introduced a model of knowledge-creating dialogues (see Figure 7.1), in which promisingness evaluation is conceptualized to be applicable to several kinds of new ideas created to fulfill a knowledge creation goal, to define immediate next steps or build coherence with a broader knowledge context. Therefore, promisingness judgments are expected to have significant implications for knowledge-building discourse.

In Studies 2 and 3, the most straightforward influence of PJs was its role in defining knowledge space for next phase knowledge-building discourse, thanks to the specially designed knowledge practices to support PJs. Coherent with Scardamalia and Bereiter’s model, in these studies PJs played an explicit role in defining the next steps of discourse. Specifically, students in both studies made PJs on their community ideas, collectively
Figure 7.1: A model of knowledge-creating dialogue. Adapted from Bereiter (2010).
decided which ideas were worth further investigation, and used these ideas to set the stage of next-phase discourse. This direct involvement of PJs has been demonstrated by Figure 6.7 in Study 3, which showed intensive synthesis efforts facilitated by PJs at the end of each phase.

Through more in-depth analysis, influence of PJ was also uncovered at multiple levels of knowledge-building discourse. At the individual level, students were found taking advantage of PJs to find emergent topics to participate in, integrate related ideas, and revise their own ideas accordingly. Although individual differences abounded among students, in many cases PJs could raise students’ awareness of promising topics or contributions within their community.

At the group and community level, PJs were found to facilitate group activities in different conceptual lines of inquiry and to foster connections among students and among ideas. In Study 2, the cohesiveness of the community’s social networks was found increasing over time. In general, PJs were also found facilitating collaboration by bringing student attention to shared problems and promoting emergence of new problems in deepening inquiry. By encouraging students to evaluate community ideas and review identified promising ones, promisingness judgments put students on a higher ground from which they may have a greater chance to spot fragments, discrepancies, and promisingness in their community knowledge space.

Moreover, a certain level of self-organization, which is conducive to conceptual growth (Bereiter & Scardamalia, 2013; Kauffman, 1993), was made possible by PJs. When traces of PJs are left in the knowledge system, as those little icons in Study 3 for instance, they become “stigmergy” (Marsh & Onof, 2008) in a social system to direct individual and group efforts towards community knowledge goals. Promisingness judgments could then become a strong engine of self-organization in knowledge creating processes.
Question 4: To What Extent Could Promisingness Judgments Facilitate Knowledge Advancement in a Knowledge Building Community?

In Studies 2 and 3 there was evidence of significant knowledge advancement, measured by either scientific sophistication of notes, conceptual pre-post tests, depth of questioning, or comparisons with domain content benchmarks. In particular, the Grade 3 experimental class from Study 2 was compared with another class of the same grade taught by a more experienced Knowledge Building teacher. The experimental class started lower but achieved results higher than the comparison group in terms of scientific sophistication.

Knowledge advancement was attributed to group dynamics set in motion by engaging students in discussion of the concept of promisingness, making PJs, discussing them, and integrating them into ongoing knowledge-building discourse. One of the most important roles of PJs is focusing limited time of a community on ideas that are most likely to bring about advancement. This has been a great challenge in Knowledge Building classrooms and knowledge-creating organizations. As shown in the case study of inquiry threads in Study 2, the first thread, which did not make much progress, was not in shortage of ideas at all; further, deeper engagement with many of them could lead to greater knowledge progress. However, students did not make deliberate decisions on which direction they should follow. As a result, problems with those ideas and misconceptions were never addressed. In contrast, an inquiry thread initiated and sustained through promisingness judgments showed continuous efforts to identify ideas of consequence and focus on them, leading to conceptual advances. Of course these contrasting threads were selected to demonstrate contrasts—one a line of inquiry with limited progress and no PJs, the other more substantial progress with PJs. We have seen sustained discourse without PJs. Nonetheless, the overall finding of increases in knowledge advancement associated with use of PJs indicates that in a variety of ways, some more obvious than others, reflective processes set in motion through PJs had an overall positive effect.
Question 5: To What Extent Could Promisingness Judgments Facilitate Personal Epistemic Beliefs of Students?

In addition to knowledge advancement demonstrated for the student community in Study 3, there was evidence that student engagement in PJs helped students’ advance toward epistemic beliefs more in keeping with beliefs associated with mature knowledge building (Chuy et al., 2010). There was no control group, so findings are tentative at best, but correlation analysis did show co-development of understanding the concept of promisingness and advances in epistemic beliefs. Since personal epistemic beliefs have been found to be broadly linked with learning (L. E. Ferguson & Bråten, 2013; Hofer, 2001; P. M. King & Kitchener, 2004a), further investigation linking PJs and epistemic beliefs (individual and social) to knowledge advancement seems a very promising line of research.

In summary, this dissertation research represents the first effort to uncover students understanding of the concept of promisingness judgment and classroom practices to help students make and sustain knowledge building discourse through their use. It explores a range of issues and presents promising results related to a new competency uncovered among young students—the ability to make promisingness judgments to advance knowledge building discourse. Of course, the research goals and results barely scratch the surface of promisingness. Theoretically, more work needs to be done in order to bring the concept into more coherent relationship with related concepts such as idea connectedness, self-organization and emergence, rise-above, metadiscourse, and promisingness. Further psychological study of promisingness judgments is needed to provide much stronger empirical data to understand the extent to which identification of promising ideas is general or domain specific, the interplay between intuition and reasoning, the role played by emotions in promisingness judgments, and so forth. And analysis of the developmental trajectory of promisingness judgments that has barely begun (B. Chen, Scardamalia, & Bereiter, 2013) needs to be extended. Classroom experimentation regarding knowledge space designs conducive to endless idea improvability—as opposed to
set phased experiments—was initiated in a graduate course in a graduate course (not included in this dissertation) (B. Chen, Scardamalia, Acosta, Resendes, & Kici, 2013), but considerable additional work is needed to advance technological and pedagogical designs for promisingness.

It is important to note that the concept of promisingness itself is in need of further analysis and model construction. In this thesis I have treated it by default as a unitary concept, while acknowledging that judgments of promisingness are knowledge and context dependent. But is it reasonable to treat promisingness as a generic skill—acquired in one context and generalizable to others—or is it better treated as a habit of mind or as a certain aspect of domain knowledge that warrants special enhancement and support? These are questions to be pursued in later work and not further considered here. The following are more specific researchable issues that I see as promising for advancing the treatment of promisingness in education. Hence, while this dissertation research has addressed several important research questions regarding promisingness, it raises even more questions leading to future work needed to expand and refine knowledge building research.

7.3 Implications for Knowledge Building Research and Beyond

7.3.1 Reinforcing Knowledge Building Principles

As shown in this dissertation research, getting students engaged with the concept of promisingness in knowledge building is both feasible and productive. The Promising Ideas tool, as a technological innovation revised throughout the studies reported in this research, represents a reasonably straightforward and accessible support for students and teachers to integrate PJs into their knowledge building work. In the three design cycles,
the tool coupled with knowledge practices showed promise of enabling meaningful integration of PJs into knowledge building discourse. By engaging students in the intentional effort of highlighting promising ideas, PJs invited them to ponder important questions such as “What are our knowledge goals?” “Where is our discourse heading?” “Are our current ideas addressing our goals?” “Which directions should we focus on to address our goals?” and so forth. These discourse moves create a discourse-about-discourse framework linking this work to current metadiscourse research within the Knowledge Building community (B. Chen & Resendes, 2012; Resendes, B. Chen, Acosta, & Scardamalia, 2013; Resendes, B. Chen, Chuy, & Scardamalia, 2012; Zhang, J. Lee, & Wilde, 2012).

Promisingness judgments advance the key principles of knowledge building in several ways. Scardamalia (2002) has highlighted twelve principles that guide design of both knowledge building pedagogy and technology. Previous research has demonstrated how these principles could guide knowledge building practices in elementary classrooms (Zhang, Scardamalia, Reeve, & Messina, 2009). Promisingness judgments provide new opportunities to deepen the enactment of these principles. Overall, the evaluation of promisingness, which is well aligned with “design-mode thinking” vital for knowledge building, further enriches principles and provide means by which they could be enacted in practice. Table 7.1 depicts a general image about how PJ can be mapped with knowledge building principles.

7.3.2 Inspiring Design of Next-Generation Knowledge Building Environments

Scardamalia (2003) defines a Knowledge Building Environment (KBE) as “any environment (virtual or otherwise) that enhances collaborative efforts to create and continually improve ideas,” and points out that “an optimal KBE will exploit the fullest possible potential of ideas to be improved by situating them in worlds beyond the minds of their creators and compounding their value so that collective achievements exceed
Table 7.1: Mapping Promisingness Judgments with Knowledge Building Principles

<table>
<thead>
<tr>
<th>Principles</th>
<th>Roles of promisingness judgments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real ideas and authentic problems</td>
<td>PJ$s$ are made as an effort to improve real ideas produced to understand authentic problems.</td>
</tr>
<tr>
<td>Improvable Ideas</td>
<td>The essential goal of PJ$s$ is to facilitate idea improvement.</td>
</tr>
<tr>
<td>Epistemic Agency</td>
<td>Evaluation of promisingness represents one of the highest levels of epistemic agency.</td>
</tr>
<tr>
<td>Collective Responsibility for Community Knowledge</td>
<td>All participants take collective responsibility when making PJ$s$, for the sake of community knowledge growth beyond individual learning.</td>
</tr>
<tr>
<td>Democratizing Knowledge</td>
<td>All participants’ contributions are equally evaluated for promisingness and all participants are all legitimate judges of promisingness; PJ$s$ are not made according to one’s status in the community, but the value of ideas for community knowledge growth.</td>
</tr>
<tr>
<td>Idea Diversity</td>
<td>While pursuing increasingly deepening discourse, PJ$s$ bring community attention to diverse ideas; this goes beyond encouraging idea diversity to providing a mechanism to connect diverse ideas to find “bigger” ones.</td>
</tr>
<tr>
<td>Knowledge-Building Discourse</td>
<td>Promisingness evaluation is an integral component of knowledge-building discourse; it depends on effective discursive practices involving students and teachers.</td>
</tr>
<tr>
<td>Rise Above</td>
<td>Through PJ$s$ students develop a stronger sense of the knowledge landscape in their community, so that rise-above$\text{s}$ integrating promising ideas can be created to guide future directions.</td>
</tr>
<tr>
<td>Symmetric Knowledge Advance</td>
<td>PJ$s$ involve substantive group deliberation making all participants more aware of contributions of others; there is recognition of expertise distributed throughout the community with greater integration of different ways of contributing.</td>
</tr>
<tr>
<td>Embedded and Transformative Assessment</td>
<td>Integrated PJ$s$ represent a form of internal assessment of community knowledge relevant to further knowledge advances; analytic tools could be created to further scaffold PJ$s$ and feed “forward” results to knowledge-building discourse.</td>
</tr>
</tbody>
</table>
individual contributions.” An effective KBE also needs to provide supports for articulation of knowledge goals, formulation of knowledge problems, preservation of ideas, and sustained knowledge-building discourse, all for supporting continual growth of ideas. Current Knowledge Forum was designed for this purpose and it is the predominant KBE to support knowledge-building discourse. Next-generation KBE is being developed in the context of an international open source team.

The study of promisingness judgments provides insights for addressing important challenges in supporting knowledge-building discourse. First of all, the design of the Promising Ideas (PI) tool extended Knowledge Forum’s current “rise-above” affordances—the challenge of elevating ideas out of their local contexts and setting them onto a new trajectory of growth, while providing links back to the local context. For instance, while the referencing function available in current Knowledge Forum can set an idea on a new course of development, this function is not specifically designed for dealing with promisingness; its support for promisingness is largely implicit and may confound with its other usages (e.g., refuting an idea). In contrast, the central goal of PI is to support PJs. After promising ideas are identified with PI, they can be reviewed together in the idea aggregation window. As a result, linkages among ideas can be more easily spotted and more advanced ideas can then be generated. In particular, with the refined exporting function in PI version 3, which exports ideas as citations to a new note, a new mechanism of rising above is supported. Meanwhile, the ease of exporting ideas or collections of ideas to a new view, as reported elsewhere (B. Chen, Scardamalia, Acosta, et al., 2013), could also help crossing boundaries and promote idea connectedness in the knowledge space. Additionally, such efforts to connect ideas and support self-organization is also depicted in an experimental map layout of the idea aggregation window, see Figure 7.2, which visualizes ideas in a way that reveals their semantic overlaps. In this layout, an edge between two ideas denotes semantic similarity between them surpassing a threshold and encourages students to explore their relations. By clicking on the edge between two linked
Figure 7.2: The map layout of idea aggregation window. In this layout, semantic linkages among ideas are visualized. The user can review two ideas together by clicking on the edge between them.

ideas, students could further inspect their connections. While such functionalities remain prototypic, experimentations of PI in this dissertation have provided new mechanisms for idea improvement.

Second, designs for promisingness judgments have highlighted new possibilities of design for self-organization and emergence in knowledge building communities. Community dynamics involving promisingness judgments uncovered in this dissertation showed promise of using the results of PJs as traces to foster self-organization among community members. By showing promisingness cues in the knowledge space, as demonstrated in Study 3, we could mimic “stigmergy” that keeps social insects coordinated. Furthermore, self-organization of people also triggers self-organization of ideas. By putting promising
ideas into different categories or tagging them with specific criteria, ideas become connected in new ways.

Third, the usefulness of promoting ideas to a higher level has prompted me to seek indicators of promisingness by harnessing new advances in learning analytics. To facilitate idea improvement, besides engaging students to make promisingness judgments, we could also turn to computational techniques for additional insights to augment human judgments. Specifically, data available in current Knowledge Forum could be mined to provide indicators of idea status. For example, traces of multiple build-ons of one idea may indicate some “promisingness” merit of this idea; linguistics features in student-written text could provide additional indicators (Rosé et al., 2008; Wang et al., 2007). These indicators could be incorporated in design of KBE to facilitate filtering and navigation of ideas. Furthermore, a variety of areas in the field of learning analytics, e.g., social learning analytics (R. Ferguson & Shum, 2012), discourse-centric learning analytics (De Liddo, Shum, Quinto, Bachler, & Cannavacciuolo, 2011), and multimodal learning analytics (Blikstein, 2013) could also potentially inspire designs for idea improvement in knowledge building. Interesting future work could be done using learning analytics techniques to scaffold promisingness judgments and to ultimately support continual idea improvement.

In summary, experimentation with various designs for promisingness in this dissertation have offered insights regarding better supports for idea improvement. Extending designs elaborated in this dissertation could enrich current KBE’s capabilities for promoting idea-centered discourse, rise-aboves, self-organization, emergence of new competencies and knowledge building analytics.

Reflecting on the journey of supporting promisingness and looking into future work, a conceptual framework for the development of future knowledge building environments involving promisingness judgments has emerged.
A Conceptual Framework for Future Development Work

Dealing with complexity. Knowledge building requires that students thrive on complexity and, in turn, work through complexity to discover simplifications that get to the essence of a complex problem space. These simplifications are important because one cannot expect to cope with everything in a complex problem space; simplifications help to keep items manageable, yet powerful enough to make breakthroughs. The “wisdom of the crowd” approach that PI depends on engages students in this process. However, there is a risk of premature simplification. Notably, some students using PI in Study 1 discussed the benefits of the tool as a filtering tool to remove the burden of reading all notes. There is risk, of course, in creating a context in which students feel they only need to read ideas marked as promising by their peers. Risks include premature simplification of the problem field, limiting idea diversity, and attention focused on ideas to the exclusion of hidden gems or to-be-discovered ideas from another source, and ideas that are not so promising after all. Thus the PI way of dealing with complexity might itself obscure more promising possibilities. Similarly, PI’s current aggregation list interface may lead students to simply ignore ideas at the bottom of the list. So getting “hits” and “clout” may overtake promisingness. Overall, the risk of premature simplification rather than working through complexity to create coherence and elegant simplifications represents a serious challenge, especially when transliteracy—the ability to find coherence out of complexity and fragmented information (Liu, 2011) and integrative thinking (Martin, 2009) require embracing rather than avoiding complexity.

Endless improvability. In Knowledge Building pedagogy, endless improvability of ideas is recommended as a working hypothesis although it is of course never fully realized in practice. Beyond selection of promising ideas is the challenge of taking them to full potential; selection is one small part of the process. Pursuing promisingness requires redirection once flaws are discovered and need for redirection as work proceeds. The goal should clearly center on building ideas into something of consequence. Accordingly
Knowledge Forum is designed to support endless improvability (Scardamalia, 2004). For example, view links support view-of-views so a view can be subsumed by a higher-order structure, views can subsume rise aboves, rise aboves can subsume rise aboves, etc. Designs for PJ provide means to push this support forward, by elevating ideas to a higher plane and flexibly moving ideas to new spaces. To bring PI with Knowledge Forum into better alignment, an important design challenge yet to be tackled is to treat the aggregated promising ideas list itself as an object of inquiry and support ways in which it can be explored for idea improvability. Innovative interface design is needed in this area.

**State of the art/“Essences”**. Knowledge Building, in line with knowledge work in the new “open informational world” requires the ability to find promising ideas and construct coherent knowledge out of fragmentary information. Complexity of knowledge practices brings about messiness in a Knowledge Forum view, which is vital for supporting endless improvability. However, the challenge of creating new syntheses and state-of-the-art analyses out of idea constellations emerges at the same time. The current aggregation list of promising ideas in PI represents a plane presumably consisting of the essences of community discourse. Nevertheless, challenges still remain to create designs that provide better support for producing state-of-the-art summaries out of the list. The challenge of moving from selection to the actual advancement of promising ideas to advance the state of the art remains a serious challenge.

**Metaperspectives/Metadiscourse**. Promising ideas evolve as knowledge builders reflect on issues such as “What aspect of the discourse is advancing?”, “In what areas are we stuck?”, and “What is the likely result of pursuing this particular line of inquiry?” Through such reflection promising ideas are identified and advanced. Such discourse about discourse is essential for knowledge building. Any artifact—promising ideas list, messy view, overview of contribution types (Resendes, B. Chen, Chuy, & Scardamalia, 2012)—will help to the extent that it serves to advance ideas. The experiment
in which the PI tool was used to export promising ideas to a new view is an example of supporting metadiscourse, and it was through this metadiscourse that group dynamics were supported. Thus, PI is complementary to, rather than a replacement for, other metadiscourse tools. Next-generation efforts will focus on designs to support revision of PI, engaging students in discussing questions such as “Can we identify a more promising idea than found on the list?” and “Does anyone remember a promising idea in our notes that did not make it on the list?” More generally, any aggregation of promising ideas provide by PI needs to serve as an object of discourse aiming at extended work with promising ideas. The power is in the discourse, while the tool must bring to the fore increasingly higher-order objects of discourse for reflection. An important next-step will be exploration of metadiscourse surrounding the promising ideas list/map itself, to extend the work with the export facility.

Assessment of discourse. Promisingness judgment is essentially about assessing community knowledge. In PI, the responsibility of assessment rests on the shoulders of students. On the other end, advances in learning analytics research have shown great promise of the machine as important player. For knowledge-building discourse in particular, because a large portion of discourse is recorded in the form of Knowledge Forum notes, textual data can be mined to assess community discourse. The Knowledge Building community has shown intense interest in this area. Previous work has applied Latent Semantic Analysis (LSA) to highlight relationships among notes based on semantic similarities (Teplovs, 2010); Latent Dirichlet Allocation has been used to model evolution of discussion topics (B. Chen, 2014; Sun, Zhang, Jin, & Lyu, 2014); a Natural Language Processing tool entitled SIDE (Mayfield & Rosé, 2010) has been applied to automatically code questioning patterns in knowledge-building discourse (Mu, van Aalst, Chan, & Fu, 2014). Other aspects of discourse that can be handled with computational methods include misconceptions in textual data (Sherin, 2012), openness to existing perspectives in conversations (Howley, Mayfield, & Rosé, 2013), and authority in dialogues (Mayfield &
Rosé, 2011). Future efforts tapping into these possibilities carries the promise of creating new social, cognitive, and emotional indicators for assessing discourse. These indicators could come together to form a network of connectedness, promisingness, and rise-above makers in discourse. These markers can serve as points of connectedness between people and ideas, allowing students to operate as more powerful epistemic agents.

In essence, knowledge work typically starts with fluid idea generation and needs multiple supports to build more complex structures. This is a self-organizing process supported through multifaceted supports for rising above—which is essentially a process of iterative work to get at increasingly promising ideas. Not any single tool is capable or expected to achieve this goal. The design challenge here is to integrate multiple affordances (e.g., notes, views, references, rise-aboves, PI) to make rise-above dynamics more transparent and accessible.

7.3.3 Revisiting the Debate of Who Controls the Zone of Proximal Development

In the field of learning sciences, for years there has been a debate over the amount of guidance students should receive in order to learn productively. Some researchers accuse instructional approaches such as problem-based learning and inquiry learning of being “minimally guided” and ineffective when compared to direct instructional guidance (Kirschner, Sweller, & Clark, 2006). Some other researchers point out scaffolding actually abounds in problem-based learning and inquiry learning and such approaches are powerful models for learning (Hmelo-Silver, Duncan, & Chinn, 2007).

Underlying this debate is the question of whether young students could take control of their own learning. For constructivist learning, the question can be further sharpened to who assumes control of students’ Zone of Proximal Development (Vygotsky, 1978). This dissertation contributes to this dialogue by showing that students, as young as 8-year-old, can take charge of the direction of their knowledge building, when provided
with proper pedagogical and technological supports. While this dissertation highlights promisingness judgments as an important competency that can co-develop with domain knowledge and personal epistemic beliefs, designing meaningful socio-cognitive supports so that students exert epistemic agency in less optimal conditions and across domains remain formidable challenges.

7.4 Closing Remarks

This dissertation provides the first empirical study of promisingness judgment, which has been recognized as an important component of knowledge-creating endeavors. In particular, this research explored the extent to which pedagogical and technological innovations could facilitate students’ PJs in knowledge-building discourse in an elementary science context. Reflecting an important characteristic of design-based research, the dissertation research was conducted in three separate design cycles. The first cycle tested the Promising Ideas tool developed to support PJs and explored different socio-cognitive configurations for PJs. The second phase implemented the first pedagogical intervention to support effective use of PI and investigated integration of PJs in knowledge-building discourse in a great detail. Informed by the first two iterations, the third phase of this research further explored the link between PJs and students’ personal epistemic beliefs. All phases involved science learning in elementary schools.

This study contributes to knowledge building research as well as the broader learning sciences research in several ways. First, it tested ways to engage students in making meaningful and productive PJs, opening doors to engage students in higher-level cognitive responsibility in creation-oriented education (Paavola & Hakkarainen, 2005). It sheds light on pivotal issues regarding students’ competency in this area. Second, it contributes to the design of next-generation knowledge building environments. Whether for building scientific explanations or creating social innovations, the evaluation of promis-
In the knowledge building context, promisingness judgments help us reconceptualize designs for rise-aboves and self-organization. Third, the study of PJs serves as a catalyst for rethinking knowledge building analytics to focus on students’ evaluating ideas and signaling the status of ideas to inform discourse dynamics. Further development of new analytic tools that are integrated into knowledge building environments have great potential for scaffolding knowledge building. Fourth, this dissertation advances the line of “negative knowledge” research in learning sciences discussed in Chapter 1 (Bickhard & Campbell, 1996; Kapur, 2008; Kapur & Bielaczyc, 2012; VanLehn et al., 2003), involving students in decision-making and giving them opportunities to learn from their successes and failures.

In summary, this dissertation has shown that, with properly designed pedagogical and technological supports, promisingness judgments could be successfully integrated in knowledge-building discourse in elementary science. After grasping the concept of promisingness through discussion, students could engage in both meaningful promisingness judgments and further work on identified promising directions. Involving students in evaluating promisingness of their ideas could facilitate individual knowledge integration, group collaboration, community knowledge advancement, and growth of individual epistemic beliefs. The pedagogical and technological supports designed in this dissertation have already been applied in other contexts to support knowledge building in elementary science, college-level engineering education, and teacher education (Boutin, 2013; Boutin & Laferrière, 2013; Hamel, 2013), and will be further refined in future research.
Appendix A

Conceptual Test of Electricity

The conceptual test of electricity used in Pilot B of Study 1 is attached starting from the next page.
Show Your Understanding of Electricity

Part 1: Draw and Explain

1. Draw a complete circuit that includes a battery, a light bulb, and wires. Use arrows to show the path electricity takes to light the bulb.

2. Explain how the electric current flows in your complete circuit to light the bulb.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Part 2: Multiple Choice and Short Answer Questions

1. Marta has a radio in her room. It requires electricity in order to play. Which of the following is necessary in order for electricity to move from the source to the radio?

   A. a circuit  
   B. a magnet  
   C. a light bulb  
   D. an insulator

2. The figures below show a light bulb connected to a battery in two different ways.

![Figure 1](image1.png)  

![Figure 2](image2.png)

When the switch in Figure 1 is closed the bulb will light. A plastic ring is inserted in the circuit as shown in Figure 2.

What will happen when the switch is closed in Figure 2?

   A. The bulb will light just as it did in Figure 1.  
   B. The bulb will be brighter than it was in Figure 1.  
   C. The bulb will light, but will be less bright than it was in Figure 1.  
   D. The bulb will not light at all.

3. Look at the objects shown below.

![Objects](image3.png)

Some of these objects are conductors of electricity and some are insulators.
a. List all the objects that are conductors.

b. List all the objects that are insulators.

c. Describe the difference between a conductor of electricity and an insulator of electricity.

4. The diagram below shows an incomplete A. circuit due to a break in the wire at point X.

A student is testing materials to see if they conduct electricity. The student places each item shown at position X, making sure the object is in contact with the loose end of each wire. Which item will electricity flow through, causing the bulb to light?

A. Crayon
B. Plastic comb
C. Notebook paper
D. Penny
5. Electricity traveling through a wire is an example of:

A. a force applied by a simple machine  
B. energy flowing through the water cycle  
C. Earth’s gravitational pull on an object  
D. energy being transferred from place to place

6. A comb is rubbed with a piece of wool fabric and placed next to some scraps of paper. The paper moves toward the comb. The movement of the paper is caused by —

A. chemical energy  
B. magnetic attraction  
C. mechanical energy  
D. static electricity

7. The picture shows the results of an experiment with an electromagnet. If the magnet had 6 turns of wire, how many pins would it probably pick up?

A. 9  
B. 10  
C. 11  
D. 12
8. Five identical lamps are connected in parallel. If one light burns out
   (a) all lights will go out
   (b) all lights after the burned out lamp will go out
   (c) the remaining bulbs will be less bright
   (d) the remaining bulbs will be unaffected
   (e) all lights before the burned out lamp will go out

9. To increase the strength of an electromagnet, use
   (a) more coils and more voltage
   (b) more coils and less voltage
   (c) less coils and more voltage
   (d) less coils and less voltage
   (e) more iron filings around the electromagnet

**Short-Answer Questions**

10. (a) Draw a diagram of a circuit that has two light bulbs, one battery and one switch in series.

(b) What will happen to the light bulb if the switch is open? Explain your answer.
Appendix B

Domain Knowledge Test of Population Growth

The domain knowledge test of population growth used in Study 3 is attached starting from the next page.
Section I: Show Your Understanding of Populations

Part 1: Draw and Explain

In a habitat lives five populations of organisms, including grass, rabbits, foxes, and hawks.

1. Draw arrows between populations to show predation relationship in this habitat. (For example, if B feeds on A, you could draw an arrow from A to B, like this: A→B.)

2. If the rabbit population is suddenly decreased because of a serious disease, what will happen with other populations in this habitat? Explain why.

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
3. If most foxes get hunted due to illegal hunting in this area, what will happen with other populations in this habitat? Explain why.

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

4. Suppose all grass dies because of a serious pollution in this habitat, what will happen with other populations in this habitat? Explain why.

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

5. Foxes and hawks usually do not eat each other. What is the relationship between them in this habitat? Explain how this relationship works.

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

Part 2: Multiple Choice and Short Answers Questions

6. The growth rate of a population of geese will probably increase within a year if ______

A. more birds die than are hatched.
B. several females begin laying eggs at younger ages than their mothers did.
C. most females lay two eggs instead of three during a nesting season.
D. some birds get lost during migration.
7. Which of the following statements about parasites is true? ______

A. The presence of a parasite does not affect the host.
B. Parasites and their hosts benefit each other.
C. Parasites always kill their hosts.
D. Parasitism is similar to predation.

8. On the Genovesa Island lives a special kind of finches with long beaks. With long beaks they are able to punch holes in the cactus fruit and eat the fleshy pulp which surrounds the seeds. Explain how these long beaks might have evolved in these finches.

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

9. Human population growth accelerated in recent centuries mostly because of ______

A. better hygiene and food.
B. the expansion of cities.
C. improved efficiency of fuel use.
D. more natural water resource.
10. **China has the largest population in the world.** To control its rapidly growing population, China introduced a “one-child policy” in 1970s. This policy effectively helps China regulate its population growth. As shown in the following graph on the left, China’s population is projected to stop growing by the year 2030. However, this policy also create problems, such as fastly aging population and gender imbalance. As shown in the following graph on the right, less children (bottom) are born recently, and a large portion of the population (middle) is aging.

If you were the person to make the decision in 1970s, what will you decide to do? Try to defend your decision with scientific concepts you know.

____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
Appendix C

Self-Report Items Used to Measure Epistemic Beliefs

The items are adapted from Conley et al. (2004).

Source

- Everybody has to believe what scientists say.
- In science, you have to believe what the science books say about stuff.
- Whatever the teacher says in science class is true.
- If you read something in a science book, you can be sure it’s true.
- Only scientists know for sure what is true in science.

Certainty

- All questions in science have one right answer.
- The most important part of doing science is coming up with the right answer.
- Scientists pretty much know everything about science; there is not much more to know.
- Scientific knowledge is always true.
- Once scientists have a result from an experiment, that is the only answer.
- Scientists always agree about what is true in science.
Appendix C. Self-Report Items Used to Measure Epistemic Beliefs

Development

- Some ideas in science today are different than what scientists used to think.
- The ideas in science books sometimes change.
- There are some questions that even scientists cannot answer.
- Ideas in science sometimes change.
- New discoveries can change what scientists think is true.
- Sometimes scientists change their minds about what is true in science.

Justification

- Ideas about science experiments come from being curious and thinking about how things work.
- In science, there can be more than one way for scientists to test their ideas.
- One important part of science is doing experiments to come up with new ideas about how things work.
- It is good to try experiments more than once to make sure of your findings.
- Good ideas in science can come from anybody, not just from scientists.
- A good way to know if something is true is to do an experiment.
- Good answers are based on evidence from many different experiments.
- Ideas in science can come from your own questions and experiments.
- It is good to have an idea before you start an experiment.
Bibliography


McElhaney, K., Matuk, C., Miller, D., & Linn, M. C. (2012). Using the idea manager to promote coherent understanding of inquiry investigations. In J. van Aalst, K.
Thompson, M. J. Jacobson, & P. Reimann (Eds.), *The future of learning: proceedings of the 10th international conference of the learning sciences (icls 2012) - volume 1, full papers* (pp. 323–330). Sydney, Australia: ISLS.


BIBLIOGRAPHY


