Promisingness Judgments in Knowledge-Building Discourse

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Statment of Problem

The ability to produce new knowledge is increasingly emphasized in the "knowledge society" (Drucker, 1994), where innovation is badly needed to solve complex problems (Homer-Dixon, 2000) and to address emerging global challenges in extensive social and cultural sectors. Education needs significant reform to respond to this trend, not only for successful economies, but also for effective cultural and social participation of citizens and for them to lead fulfilling lives in the knowledge era (Centre for Educational Research and Innovation & Organisation for Economic Co-operation and Development, 2008). Regardless of this need, however, most educational systems still operate much as they did one or even two centuries ago (Cuban, 1993). Education is facing criticisms for not being able to prepare qualified employees for the emerging knowledge economies. According to a survey, over two-thirds of employers said that high school graduates were deficient in problem solving and critical thinking (Barth, 2009); from a different perspective, skills that are found highly needed by college graduates in their work, such as defining problems (Gillmore, 1998), are not explicitly tackled in most schools. The critical gap between our need for innovative knowledge workers and the actual ways we educate younger generations calls for rethink on our current educational systems.

One of these efforts to rethink education comes from the endeavors to define and teach "21st century skills" (e.g. Binkley et al., 2012; Hilton & National Research Council Board on Science Education, 2010; International Society for Technology in Education, 2007; Partnership for 21st Century Skills, 2009; The European Parliament & The Council of European Union, 2006). These endeavours aim to recognize and bring people's attention to the skills, knowledge, and attitude that traditional education fails to value but are increasingly important in the new century. A list of such skills usually include creativity and innovation, critical thinking and problem-solving, communication and collaboration, information and ICT literacy, citizenship, and global awareness. Critics levy strong arguments against the push for these skills, decrying so-called 21st century skills as a meaningless term and a distraction from teaching the more important core content and "hard" skills; they declare that knowing how to think critically, analytically, and creatively are not skills specific or unique to the 21st century (Silva, 2009). Nevertheless, as research about the evolution of the workforce in the past decade shows, work that only requires routine skills is more often done by computers (Levy & Murnane, 2004); 21st century skills, as a result, are not necessarily new, but becoming newly important (Rotherham & Willingham, 2009). Thus, to prepare qualified workers and citizens for the new century, schools need to teach 21st century skills.

However, although different committees around the world usually come up with similar lists of 21st century skills, there is a heated debate about how to teach these skills (e.g. Schrier, 2006; Trilling et al., 2009; Walser, 2008). Among presented options, adding a new and separate set of skills to an already crowded curriculum seems both impossible and unnecessary. As studies by national and international organizations have shown, complex thinking and analytical skills are an integral part of learning at every stage of development (Darling-Hammond et al., 2008; Kozma, 2003; Bransford et al., 2000; Organisation for Economic Co-operation and Development, 2004); skills and content are best learned together but not separately (National Mathematics Advisory Panel, 2008). Therefore, instead of imparting these skills individually, we need to bring about a systemic change to our school practice, to teach students these knowledge and skills important for knowledge creation in a coherent and integrated manner.

Knowledge building represents an attempt to refashion education in a fundamental way, so that it becomes a coherent effort to initiate students into a knowledge creating culture (Scardamalia & Bereiter, 2006). Knowledge building may be defined as "the production and continual improvement of ideas of value to a community" (Scardamalia & Bereiter, 2003, p. 1370). In knowledge building, members of a community share *collective responsibility* for advancing communal knowledge by engaging in explanation-seeking dialogue and theory development. In education, Knowledge Building pedagogy represents a constructivist approach rooted in research on expertise and innovation (Bereiter & Scardamalia, 1993). Like scientists, artists, engineers, and others in knowledge-creating organizations (Dunbar, 1995; Nonaka, 1991), students engaged in knowledge building participate in constructive and progressive *knowledge-building discourse*, in which they contribute to group dialogue in distinctive ways, including proposing theories, synthesizing ideas, and making analogies (Chuy et al., 2011). Knowledge Building requires that students take collective responsibility for knowledge advancement, a responsibility normally assigned to teachers. Accordingly, students are engaged in efforts to intentionally advance the frontiers of their community knowledge, not merely following tasks or activities set by teachers (Scardamalia, 2002). The high level of agency transferred to students places this pedagogical model at the far end of a continuum from shallow to deep constructivism (Scardamalia & Bereiter, 2003). In this model, students need to identify problems of understanding, establish and refine goals, gather information, theorize, design experiments, improve ideas, monitor and evaluate progress, all to achieve their knowledge building goals. Accordingly, Knowledge Building pedagogy involves students "not only developing knowledge-building competencies but also coming to see themselves and their work as part of the civilization-wide effort to advance knowledge frontiers" (Scardamalia & Bereiter, 2006, p. 97).

Continual seeking of idea improvement is central to knowledge building (Scardamalia & Bereiter, 2006), as creating new knowledge entails expectation and means for going beyond the knowledge frontiers. Knowledge-creating goals are *emergent goals*; the best assumption is that ideas are improvable and may grow from nascent form to something of greater consequence than planned initially. In line with this emergence perspective, a knowledge-building approach considers the "*promisingness*" of an idea, recognizing that through new combinations and sustained work something of substantial value might emerge. A significant challenge in all creatie work, in both the fine grain and the large, is to identify promising ideas and avoid wasting resources on unpromising ones. As Bereiter and Scardamalia (2003) argue, the ability to recognize promisingness is what distinguishes creative experts from experienced non-experts. Thus, the capacity to evaluate promisingness of ideas could justifiably gain a place among the the knowledge creation skill set.

Making promisingness judgments does not appear on 21st century skill lists, however, possibly because little is known about what students are capable of in this respect and little attention has been given to it. At this moment, we have little clue about how this newly recognized facility functions in individual and collective minds as well as whether there are means to increase the quality of promisingness judgments. Moreover, the capacity to recognize promisingness in knowledge-creating initiatives is inherently more difficult to assess than hard skills that figure prominently in educational standards. The purpose of this study is to investigate the nature of promisingness evaluation, looking for roles it could play in progressive knowledge-building discourse, and building tools or environments to support its development.

Promisingness Judgments

The term of "promisingness" was originally introduced in the book *Surpassing Ourselves: An Inquiry into the Nature and Implications of Expertise* (Bereiter & Scardamalia, 1993), and was further elaborated in a later book *Education and Mind in the Knowledge Age* (Bereiter, 2002). However, in the past two decades this term has seldom appeared beyond the knowledge building community and there is little research to address this concept. This makes a literature review on promisingness difficult.

In this chapter, I am trying to broaden the scope from education to various domains, to present research or practice that can inspire our thinking of promisingness. In order to deepen our understanding of promisingness, I attempt to answer the following basic questions about promisingness: what does promisingness mean, why is it important, and how people make promisingness judgments. The first section will discuss the literal meaning of promisingness, by consulting respected dictionaries and thesauri. The second section will explore extensive presence of promisingness in various creative processes. The third and fourth sections will try to construct a descriptive model of promisingness, by mapping promisingness in the idea space with that in the nature and venture capital industry. Then, in order to get a deeper understanding of promisingness judgments for pedagogical and technological design, the fifth section will dive into psychology literature looking for psychological foundations of promisingness judgments. In the last section, I will try to situate the proposed research on promisingness into education and curriculum studies.

The Meaning of Promisingness

The English word *promise* was introduced from Latin words *prōmissa*, *prōmissum* and *prōmittere* around 1400AD. For prōmittere: pro- "before" + mittere "to put, send." So the ground sense of "a promise" is "declaration made about the future, about some act to be done or not done." The verb "promise" was entered 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, 2007a). 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. 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 an idea 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 (2007b, 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 (1993) coined the term "promisingness" within the context of creative expertise. They regard 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. As they argue, what distinguishes creative experts from noncreative ones is the ability to recognize promisingness in the fuzzy front-end of knoweldge creation (p. 135). The meaning of promisingness in their account implies the three constructs discussed above.

Judgments of Promisingness in the Creative Process

The history of scientific progress can be told as the story of abandoning time-honored theories or paradigms in favor of more promising ones (Kuhn, 1977). For instance, in the 16th century, Copernicus' heliocentric cosmology refuted the predominant geocentric model and stimulated further scientific investigations; in the 19th century, the religious belief that explains adaptations of creatures as a special act of God was placed in different perspective by Darwin's big idea of evolution by natural selection. In the history of science, the gradual and relentless probing of knowledge frontiers for better theories is central to the scientist's work. In their work, scientists are usually confronted with "knowledge-poor" circumstances, where principled knowledge about that problem space is scant (Bereiter, 2009). As a result, many competing ideas, usually in their preliminary forms, may emerge at the same time, and to achieve a creative goal scientists have to make decisions of uncertain result. In these circumstances, a significant challenge in scientific inquiry is to identify promising ideas—ideas that in their nascent form may not seem like much but that with development could grow into something big. In his study of scientific reasoning in real-world laboratories, Dunbar (1995) found that scientists tend to evaluate their projects in terms of risk and promisingness; scientists are keen to work on promising projects that had the prospect of being an important discovery although it may also have high probability of failure. The capability of recognizing promisingness is one key manifestation of "creative expertise" (Bereiter & Scardamalia, 1993). Creative experts could rely on their knowledge of promisingness—knowledge acquired over time as people engage in creative practices, taking risks and learning from the successes and failures—to identify more promising directions (Bereiter & Scardamalia, 1993, p. 135).

Promisingness judgments are not only evident in science laboratories, but also in many other fields and professions that involve creative processes. For example, in de Groot's (1978) 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 masters do not necessarily consider more options than experienced chess players; they simply think of better possible moves. Thus, what distinguishes masters from experience players is the ability to recognize promising moves 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 from many fields such as science, psychology, politics, economics, and art (Pahl et al., 2007). While there are usually a set of design axioms to follow (Hazelrigg, 1998), the real difficulty of solving those problems often lies not upon identifying alternative courses of action and evaluating them, but on recognizing more fruitful approaches directly from complex situations (Schunn et al., 2005). In competitive sport, players usually need to make real-time evaluation based on current information intake, and act according to the most promising moves they identify (Klein, 2008; Lehrer, 2010; Zsambok & Klein, 1997). For expert athletes, the best or most promising option often comes to mind quickly and intuitively, regardless of complexity they are facing (J. Johnson, 2006). In fine arts, painters make brushstrokes on the promise of advancing the artistic goal of the painting, with the painting as a whole conceived on the basis of an idea or image judged to be promising, within perhaps an unfolding body of work the artists feels to be promising, and quite possibly in the broader context of an emerging movement perceived to be promising. The same story can be told of the creative writer, chemist or engineer. In summary, promisingness judgments are prevalent in extensive territories of human societies.

In contrast to the far-ranging presence of promisingness judgments, there is hardly any literature that specifically focuses on promisingness. Theoretical discussions are brief, issues and methods tentative and empirical evidence scant. A half century research on creativity has mainly focused on explaining originality (e.g. Andreasen, 2005; Koestler, 1995; Gruber, 1981), and provides little ground to build promisingness research on. Decision making and judgment has attracted research attention from many fields, such as economics, political study and medicine, and may shed light on the study of promisingness judgments. However, promisingness judgment is different from other types of judgment in that it operates in a creative, emergent context where achieving improvement or progress is the central goal. Judging promisingness of a theory may not be interpreted in the same way as making a medical diagnosis decision. Therefore, although research of decision making and judgment can help us better understand social, cultural, and/or psychological processes that involve in promisingness judgments, the research of promisingness judgments still needs to centered on promisingness and knowledge creation.

Darwin's Evolution Tree: Features and Environmental Constrains that Construct Promisingness of Species

Analogies 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, by making analogy to other spheres we may sharpen our understanding of it. Among many possible analogies, the struggle of life in nature provides a promising 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 phenomena of living things—*adaptation* and *diversity* (Mayr, 1982)—which have been intensively discussed by naturalists at his time. *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). Central to this idea is that individuals with variations that help them become best adapted to their environments are more likely to survive, reproduce and maintain those winning characteristics 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 how the process of "descent with modification" could occur.

Darwin's bold insight is to apply this vision to all of life, envisioning 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, i.e. the *Tree of Life* (Darwin, 1872, p. 104-105). In this tree (see Figure 1), each new species springs from the parent tree like a shoot. These shoots branch and divide, and then turn, and so on. Some branches die out, others keep developing. The trunk is the ancient common ancestor from which all animals and plants derive.

Reflecting on Darwin's theory, features of living organisms provide a "design space" which produces infinite diversity of design. In the design space of a single species, design is constantly revised over time, bringing new designs to its diversity. This allows many directions this species could approach. However, depending on the environment and that

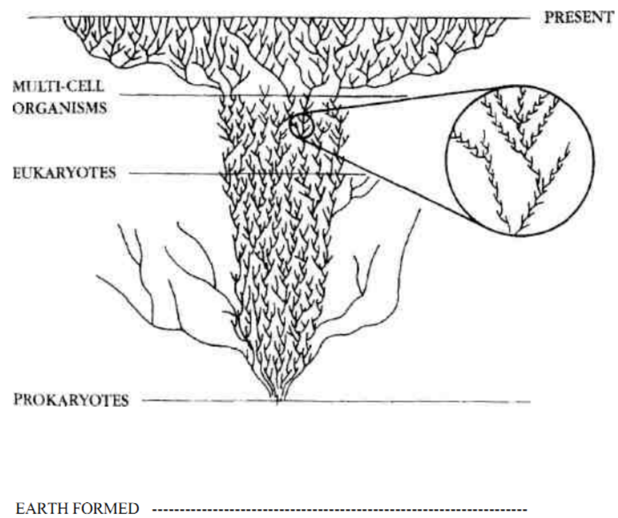

Figure 1. Tree of life, adapted from *Darwin's dangerous idea*, (Dennett, 1995, p. 89)

specific crunch time of life struggle, some directions present to be more promising than others. As a result, offspring of these branches will thrive and others will die. On this magnificent Tree of Life, a few things related to promisingness need to be highlighted:

1. Promisingness of mutations in a species is defined by the interplay between environmental factors (e.g. resources, weather and diseases) and various features of the species (such as longer beaks, more complex eyes, thick feather, etc.).
2. This 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 "makeup" or biography, but more on what happens to subsequent generations—if any—of its offspring.
5. Last but not the least, sexual reproduction brings a remarkable new change to the game, by giving each offspring its own unique DNA sequences. This brings more diversity to the design space, making promising mutations emerge more frequently, and thereby boosts evolution.

Meaningful analogies could be made between the Tree of Life in the history of evolution and the "*Tree of Ideas*" in the history of innovation. While on the Tree of Life diversity of design allows promising mutations to emerge and eventually be selected by the nature, similarly, occurrence and growth of innovative ideas in human society requires diversity, connections, and mating (S. Johnson, 2010). For example, Darwin's own idea of natural selection itself was the offspring of earlier ideas such as adaptation, diversity of life, and Malthusian vision of population (Dennett, 1995; Montgomery, 1988). Also, there were hundreds of thousands of ideas in human history which became reproductively isolated and eventually extinct, just like those dead ends on the Tree of Life. By making analogies with promisingness on Darwin's Tree of Life, I hypothesize promisingness judgments on ideas also share those five characteristics highlighted above:

1. Promisingness of an idea is defined by the interplay between its various dimensions of 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. While people can evaluate promisingness of an idea when it emerges, they cannot be sure whether it will eventually succeed.

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

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

With this conceptual understanding, the next section will introduce promisingness judgments in other fields or professions, as an effort to further elaborate the understanding and develop a conceptual model of promisingness judgments.

Promisingness Judgments in High-Risk Decision Making Processes

The venture capital industry represents a place where the evaluation of promisingness resides in the heart of day-to-day work. Venture capital firms are "those organizations whose predominant mission is to finance the founding and early growth of new companies" (Gupta & Sapienza, 1992, p. 349). To maximize revenue of their investment firms, venture capitalists' primary job is to identify ventures that show promise of high potential returns (Sahlman, 1990). Therefore, to decide on whether to invest in a venture is a prime example of promisingness judgments.

The decision to invest in a venture is a difficult one with serious adverse selection risk (Fried & Hisrich, 1994), just like investing resources in a scientific idea (Dunbar, 1995). While the venture capital industry has helped create many successful enterprises, such as Apple, Intel, and Federal Express, it has also been involved in some spectacular failures (Sahlman, 1990). Hence, selecting ventures is always a risky business, no matter how experienced a venture capitalist is and how strict a screening procedure is followed.

Given the variance of successes and failures in ventures, many researchers have studied how venture capitalists make investment. Early studies have been mainly focused on two aspects: what *process* do venture capitalists go through before placing an investment, and, related to that, what *criteria* do they use to evaluate potential investments. For the process of venture capital decision-making, most previous studies favored a sequential model. Tyebjee and Bruno (1984) modelled the investment activity of venture capitalists as an orderly process involving five steps, including *deal origination*, *deal screening*, *deal evaluation*, *deal structuring*, and *post-investment activities*. Similarly, Fried and Hisrich (1994) proposed a model which involves 6 sequential stages: *origination*, *venture capital firm-specific screen*, *generic screen*, *first-phase evaluation* (to determine whether there is serious interest in a deal), *second-phase evaluation* (to identify obstacles to the investment and ways to overcome them), and *closing*. Regardless of differences in steps, shared across these models is the interaction between information collection and venture evaluation activities. To make a judgment, venture capitalists collect extensive information from various sources such as entrepreneurs interview, facilities tour, and market investigation (Fried & Hisrich, 1994), and use collected information to form their judgments. It is widely accepted in both venture capital practice and research that the whole process is guided by some generic criteria.

Criteria used by venture capitalists to evaluate new venture proposals is a popular research topic. By deploying a questionnaire among 41 venture capital firms in the United States, Tyebjee and Bruno (1984) collected capitalists' rating on 23 characteristics of deals they were considering. Five underlying dimensions, including *market attractiveness*, *product differentiation*, *managerial capabilities*, *environmental threat resistance*, and *cash-out potential*, emerged as determinant factors for investment decisions. Adopting the same methodology, Macmillan, Siegel and Narasimha (1985) identified five dimensions of criteria similar to Tyebjee and Bruno's, including *entrepreneur's personality*, *entrepreneur's experience*, *characteristics of product/service*, *market characteristics*, and *financial considerations*. Among these dimensions, they found the quality of entrepreneur, more specifically, entrepreneur's experience or personality, ultimately determined the funding decision. By adopting a case study methodology, Fried and Hisrich (1994) identified fifteen common evaluation criteria, which expanded upon the three basic constructs: *concept*, *management*, and *returns*. There are many other studies that focus on generic criteria to make venture capital decisions (e.g. Goslin & Barge, 1986; Hall, 1993; Macmillan et al., 1987). While different studies may have arrived at different results, generic criteria identified by them appear to fit into four categories: *entrepreneur/team capabilities*, *product/service attraction*, *market/competitive conditions*, and *potential returns if the venture is successful* (Zacharakis & Meyer, 1998).

One underlying assumption of these studies on process models and evaluation criteria is that decisions in venture capital investment are made through rational analysis, based on objective and quantitative information. However, a few studies have questioned the rationality of judgment in venture capital investments. As decision-making literature shows, decision makers are not perfectly rational; their rationality is usually bounded by the limitation of accessible information, time, and cognitive resources (Cyert & March, 1992; Newell & Simon, 1972; Simon, 1955). This "bounded rationality" also applies for decisions in venture capital investments. First of all, the rationality of venture capitalists' decisions is usually limited by the information they have access to (Zacharakis & Meyer, 1998). Because the venture capitalist is not observing the venture's ultimate outcome, but instead inferring the venture's potential based upon a number of observable information factors, venture capitalists may not make sound judgment without access to crucial information. On the other hand, venture capitalists are often faced with information overload; the multitude of available information surrounding the investment decision could hinder the capitalist's judgment because of their cognitive contrains (Zacharakis & Meyer, 1998). Moreover, venture investment is often faced with serious time pressure (Baron, 1998), as speed is critical in the entrepreneurial environment where a new venture needs to launch while the "window of opportunity" is still open (Busenitz, 1999). These limitations eventually determine that the assumption that venture capitalists judge promisingness through a rational process is flawed.

As the rationality of venture capitalists is bounded, intuition, "personal chemistry" or "gut feeling" often play a role in their judgments (Khan, 1987; Macmillan et al., 1987). Although information used by capitalist is highly quantified, subjective, qualitative evaluations about the information lie at the heart of the decision to be made (Hisrich & Jankowicz, 1990). Defined as a "felt awareness for a situation as a whole" (Bastick, 1982), intuition involves an integration of disparate information and the formation of judgmental decisions. In contrast to analytic thinking, which operates in a serial mode and needs deliberate control, intuitive thinking is capable of dealing with complex tasks, such as chess playing (Chase & Simon, 1973) and credit decisions by bank loan officers (Lipshitz & Shulimovitz, 2007), through extensive information processing quickly and effortlessly (Betsch & Glöckner, 2010; Kahneman, 2003). Intuitive thinking can be powerful and accurate. Klein (2003) has argued that skilled decision makers often do better when they trust their intuitions than when they engage in detailed analysis. In venture capital, while capitalists may draw on a common set of criteria when making decisions, research shows they usually relate criteria differently, by following intuition, and form their overall judgment of a proposal by focusing on different groupings of the criteria (Hisrich & Jankowicz, 1990).

To summarize, investment decisions in venture capital represents a kind of promisingness judgment in a high-risk environment. Features of promisingness judgment discussed in the last section are manifest in investment decisions:

1. promisingness of a venture is usually judged by a common set of criteria composed of dimensions including product, entrepreneur, and market environment;
2. promising ventures come with unpromising ones, with the screening and evaluation activities conducted by venture capitalists to identify most promising ventures from many others;
3. the venture capitalist is not observing the venture's ultimate outcome, but instead inferring the venture's potential based upon a number of observable information factors; so they cannot know for sure whether a venture will turn out to be successful, even if it looks promising; and,
4. after a venture is picked for investment, the venture capital company will keep playing an important role in development of this venture, by providing valuable assistance in management and many other domains (Baum, 2004; Gladstone & Gladstone, 2004; Tyebjee & Bruno, 1984).

Research on investment judgments in venture capital provides a valuable angle to better understand the nature of promisingness judgment. As discussed in venture capital literature, rational analysis and intuition are both playing a role in venture capitalists' decision making and judgment. In the decision-making process, venture capitalists collect a multitude of information, most of which is highly quantified, and evaluate it by weighting a set of criteria or factors. At the same time, many studies show that qualitative and subjective information also plays a role in venture capitalist's judgment. Venture capitalists may intuitively integrate information from their experience and evaluate promisingness of a venture.

Drawing from the analysis of venture capitalist's decision-making, I would like to propose a descriptive model of their promisingness judgments (see Figure 2). First of all, promisingness judgments are guided by specific goals, such as achieving high investment returns in the case of venture capital. Depending on the specific circumstances, such as lack of information and time pressure, promisingness judgments may rely on rational analysis or intuition, or both. On the rational side, criteria that are defined by goals will determine what information about the basic unit of judgment needs to be retrieved; they will also guide the analytic process which involves weighting of a variety of factors. A person's knowledge and experience will play a role in analyzing and monitoring this process. The intuitive process operates very quickly, mainly by mapping information cues around the unit for judgment with previous experience. Results of this process will be integrated with output from analytic process to form the final promisingness judgment.

This model is simplistic and preliminary. It lacks a lot of details and needs further elaboration, especially in explaining the psychological process of promisingness judgments. Al-

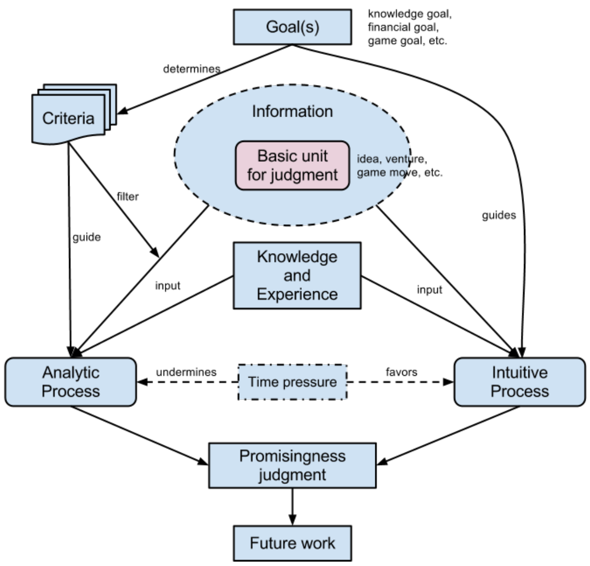

Figure 2. A descriptive model of promisingness judgment

though researching promisingness in the context of knowledge creation seems to be more meaningful, as discussed in a previous section, to get a deeper understanding of the psychological process underlying promisingness judgments would inform further research.

Psychological Foundations of Promisingness Judgments

Although the ability to identify promising ideas is essential for creative work with ideas, the process of promisingness judgments remains unexplored. 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 that consists of attitudes and intuitions about things in various contexts (Bereiter, 2002). For example, it could happen that we have a feeling that a direction could lead to success but we cannot tell the reason why we have this feeling or reasons and evidences at our hands run contrary to the feeling. In many circumstances feelings and impressions can offer us guidance while reason and evidence cannot. Thus, although feelings, intuitions and impressions are typically not considered knowledge per se (as for instance, widely recognized “declarative” and “procedural” knowledge), they could considerably influence our actions in a sound way. Promisingness judgments, as Bereiter (2002) argues, more rest 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 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). Stanovich and West (2000) propose a two-system model, labeling intuition and reasoning respectively as *System 1* and *System 2*. The operations of System 1, i.e. intuition, are usually fast, parallel, automatic, effortless, associative, implicit, and emotional, whereas the operations of System 2 are slower, serial, effortful, more likely to be consciously monitored and deliberately controlled. According to this model, the operations of intuition generate impressions of the attributes of an object based on information from current stimulation and/or long-term memory. Because judgments are always intentional and explicit, in some cases, impressions generated by intuition may get modified by reasoning. It is legitimate to say that in some circumstances, intuition is favored, while in some others, reasoning becomes more dominant.

Comparing to rational processes, which tend to disrupt each other and cannot work simultaneously, intuitive thoughts are highly accessible, coming much more easily (Kahneman, 1973, 2003; Pashler, 1998). This gives intuitive thinking a certain extent of advantage because they can operate in the background only being marginally constrained by cognitive capacity. By studying fireground commanders, officers in the military, chess players, and many other professionals working in high pressured decision making positions, Klein (1998; 2008) comes up with a “Recognition-Primed Decision (RPD)” model of how experienced people can make rapid decisions. This model reduces decision making to three types of cases: the simplest case is one in which the situation is recognized and the obvious reaction is implemented; a more complex case is one in which the decision maker performs some conscious evaluation of the decision option before action; the most complex case is one in which the intuitively recognized option reveals flaws and needs further information for modification. As a few studies shows, in rapid decision making situations, experienced people, e.g. fireground commanders, are not rationally comparing possible options but carry out the first course of action that intuitively comes to their minds (Klein, 1999; Lipshitz et al., 2001). Therefore, the decision is primed by the way the situation is recognized and not completely determined by the recognition. In this model, experience is 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 recognitional approach—is taking control. These studies shed light on our understanding of promisingness judgments.

Intuitive thinking has its advantages and disadvantages. On the one hand, intuitive thinking can be powerful and accurate. For people who have acquired high skills from prolonged practice, the performance of skills is rapid and effortless. And intuitive thoughts are much more accessible (Kahneman, 2003). Master chess players can perform intuitively (Chase & Simon, 1973), so as experienced nurses (Benner, 1984; Benner & Tanner, 1987) and surgeons (Gawande, 2002). Klein (2003) has argued that skilled decision maker often do better when they trust intuitions. Intuition is conceived as a source of knowledge, a particular process or even a structure of the brain (Winerman, 2005). However, intuitive thinking can also be inaccurate in many cases. Activities of System 1 needs to be monitored by System 2 (Gilbert, 2002; Stanovich & West, 2002). But the usual case is that the monitoring is quite lax and allows many intuitive judgments, including erroneous ones, to be expressed, especially when System 2 is occupied by other tasks (Kahneman & Frederick, 2002). Thus, it is debatable how intuition and reasoning are combined in various contexts of human judgment and decision making.

In promisingness judgments, intuition would play a major role if the agent's experience is abundant and recognition is easy to make; however, when there are certain goals or when experience is scant, an analytic mode involving a set of criteria will be activated. Building on the descriptive model of venture capital investment, I propose a hypothetical model of promisingness judgments, combining research findings in judgment and decision making literature (see Figure 3). The simplest case is one in which the judgment situation is recognized and directly mapped to prior experience of success or failure. In this case, a judgment of promisingness is directly made. This mode will only work effectively for people who have a lot of experience in knowledge creation, with both successful or failed cases, to rely on. For people who do not have rich experience, or when the situation get more complex, experience recognition alone cannot produce a sufficient judgment. In this case, people will deliberately search for more information from the situation and apply a certain list of criteria to evaluate it. For example, when evaluating a new theory, while a scientist may have a gut feeling that it is promising, she may also apply Kuhn's (1977) five criteria to evaluate its promisingness, considering accuracy, consistency, scope, simplicity, and fruitfulness of this theory. Results of rational analysis will be integrated with output from fast recognition to form an updated judgment. This process may carry on for several iterations before achieving a final judgment.

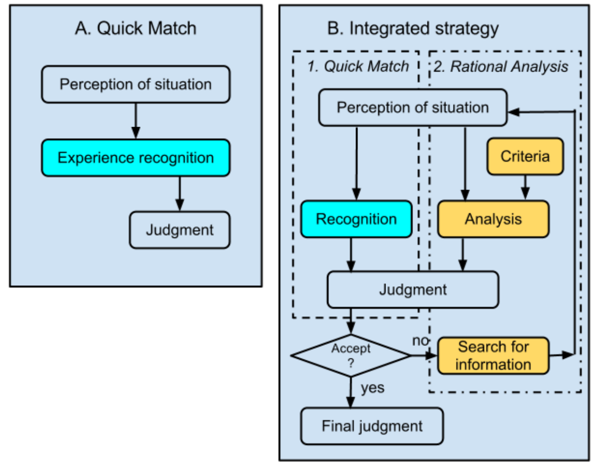

Figure 3. A psychological model of promisingness judgments

Situating Promisingness in Curriculum Studies

Building on Sfard's (1998) two metaphors for learning, namely the *acquisition* and *participation* metaphors, Paavola and colleagues (2004) propose a third *knowledge-creation* metaphor as an important aspect of education in a knowledge society. For the knowledge-creation learning model, they argue that education should go beyond pure propositional and conceptual knowledge, and put more emphasis on hidden or tacit knowledge which is highlighted in three models of knowledge creation (Bereiter, 2002; Engestrom, 2001; Nonaka & Takeuchi, 1995). Bereiter and Scardamalia (1993; 2002) argue that the capacity of making promisingness judgments, which is for them one form of tacit knowledge, is an essential resource of creative experts. For education in a knowledge-creating society, an open question is the relation between student capability of recognizing promisingness and student success in learning by and for knowledge-creation.

Although promisingness evaluation is an essential component in knowledge creation, in practice, education at all levels by and large ignores the capability of students to recognize promising ideas. In most constructionist pedagogies, student activities are usually heavily scripted by teachers and students show little awareness of directions they follow. Students concentrate on the solving of presented problem but are seldom given any chance to find, formulate, or invent problems (Dillon, 1982), so as to reflect on their ideas in terms of promisingness. Given the newness of the field and absence of pedagogical models for addressing the concept of promisingness, there is very little in the way of research to guide either teaching or learning in this area. The misconceptions or preconceptions literature suggests that students can spend a great deal of time with ideas considered unpromising (Clement, 1982; Halloun, 1985; McCloskey, 1983; Viennot, 1979; Vosniadou, 1991). The current research aims to uncover means to keep them on a promising trajectory.

Knowledge of promisingness, as a type of implicit knowledge, is much harder to recognize directly, partly because its change within a short period of time is barely noticeable. This may raise a serious doubt among people as to how could we possibly teach promisingness, especially in such assessment-driven educational systems (Glatthorn et al., 1998; Ramirez, 1999). Hakkarainen and Sintonen (2002) argued that it is entirely possible, in an appropriate environment with computer-support for collaborative learning, for young students to engage in a sophisticated interrogative process of inquiry analogous to scientific inquiry (Hintikka, 1999). People generally seem to have some insight into their implicit knowledge and such insight could increase with experience (Mathews et al., 1989). If we give students enough opportunity to practice promisingness judgments in their own course of inquiry with appropriate technological aid, their knowledge of promisingness would have better chance to grow. Given the importance of feedback in acquiring effective intuition (Hogarth, 2001), which plays an important role in promisingness judgments, it is important to implement feedback loops for students' judgments. By taking risks in their inquiry and learning from their successes and failures, their capability in recognizing promising ideas is expected to grow. Further studies are needed to determine whether this could really happen and how to measure it.

Research Questions

Situated in Knowledge Building theory and practice which attempt to transform traditional educational practice to a coherent effort to initiate students into a knowledge creating culture (Scardamalia & Bereiter, 2006), the proposed study seeks to find ways to increase students' capability in making promisingness judgments in their work, to prepare them to be future creative achievers in various fields. In this study, I will try to tackle the following central research questions:

- Firstly, to what extent can young children conduct promisingness judgments on ideas emerging in their knowledge-building discourse?
- Can developmental patterns in promisingness judgments be identified based on selections of ideas according to various criteria, such as "promising for continued group work," "promising for advancing on an unsolved problem," "promising to advance an idea I don't understand," "promising to address a misconception"? If there is a developmental trajectory of such promisingness judgments, how is it be related to expertise in the relevant subject matter?
- Is it possible to increase the quality of student's judgments and help them move faster along the development trajectory?
- Presuming the ability to differentiate between high and low quality promisingness judgments, to what extent does selection of higher quality judgments lead to knowledge advancement in knowledge-creating dialogue?

Method

Design-Based Research with Embedded Developmental Questionnaire Data to Assess Promisingness Judgments

Inquiry into promisingness will be developed using a "design-based research" methodology (Barab & Squire, 2004; Collins et al., 2004). Recent interest of design-based research can be traced back to the invention of the term "design experiments" by Brown (1992) and Collins (1992). Design experiments were developed as a way to carry out formative research to progressively test and refine educational designs based on theoretical principles derived from prior research (Collins et al., 2004). As Collins and colleagues (2004, p. 18) explain, design experimentation involves putting a first version of a design into the world to see how it works, and then constantly revising the design based on experience. Different from highly-controlled experiments, design-based research is geared to address complex problems in real-world contexts where many variables cannot be controlled (Collins, 1999; Collins et al., 2004; Wang & Hannafin, 2005). Instead of trying to control those variables, design researchers try to render plausible solutions to these complex issues by integrating known and hypothetical design-principles with technological affordances to optimize the design as much as possible. In collaboration with practitioners in real context, they will further test and refine innovative learning environments as well as its design-principles by conducting rigorous and reflective inquiry. By producing findings that are fed back into further cycles of innovative design (Bereiter, 2006), design-based research strives to advance both practical and theoretical developments and to understand more deeply the relationships between them (The Design-Based Research Collective, 2003). While design-based research is especially helpful for developing, enacting, and sustaining innovative learning environments, it can also be useful to achieve advances in theory and pedagogy. The essence of design-based research is the goals for sustained innovation of education (Bereiter, 2006) and developing evidence-based theoretical knowledge about learning (Barab & Squire, 2004). Design-based research is more likely to lead to effective real-world impact and application because it is conducted in authentic settings and because researchers collaborate closely with practitioners, engineers, and any others who operate within the given scenario or context (The Design-Based Research Collective, 2003).

The main goal of this research is to look for ways to increase students' capability in making promisingness judgments in knowledge-creating discourse. This goal calls for theoretical, pedagogical, and technological innovations that go beyond the state-of-art of educational practice. Therefore, the design-based research approach is a natural fit for this study. However, it is necessary to note that due to the highly contextualized nature of design-based research, this

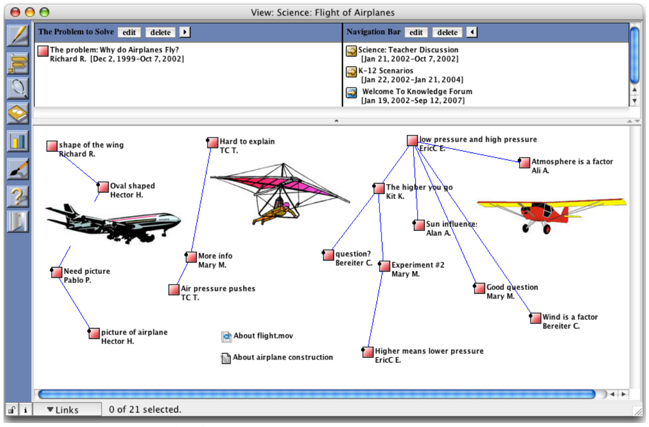

Figure 4. Knowledge Forum

approach does not have a fixed method but is often comprised of an integration of a variety of qualitative and quantitative approaches. For example, students at different ages and with different levels of expertise in different subject-matter areas will be asked to make promisingness judgments and results will inform next-generation designs.

The Promisingness Tool

To prepare young generations to be future creative achievers in various fields, we should invite them to take risks during knowledge building work and practice making promisingness judgments on their own ideas. This goal calls for new designs of innovative environments specifically targeting promisingness judgments. In schools which are committed to knowledge building practice, students make wide use of *Knowledge Forum* (Scardamalia, 2004), an online, community space designed to support Knowledge Building pedagogy. In Knowledge Forum, students contribute ideas, questions, evidence, and so on, as multimedia *notes* into a collective knowledge space. Students can organize notes thematically into *views* (see Figure 4), which serve as workspaces for various inquiry goals. Knowledge Building features within the environment include the ability for users to build on, annotate, and co-author notes, as well as make reference links to other notes. *Rise-aboves* which combine ideas from multiple notes are used to represent advances in understanding and higher-level conceptualizations. Knowledeg Forum also provides customizable scaffolds to support framing of different types of contributions.

To engage students in promisingness judgments during their knowledge-building discourse, I have been engaged in the development of a "Promising Ideas tool" seamlessly integrated with Knowledge Forum (Author et al., 2010). This tool will require many iterations of design experiments, during which its design principles and functionalities will be progressively revised (see for example, Author et al., 2011; Author et al., 2011).

An early prototypic version of the Promising Ideas tool integrates various functions such as highlighting, tagging, and visualization of ideas, enabling students to collaboratively evaluate the community's ideas. Currently this tool is composed of three components (see Figure 5): (a) a highlight feature that allows students to tag an idea within a Knowledge Forum note using a customizable categorization scheme; (b) a window that aggregates all selected ideas within a same view, merges overlapping ideas, and visualizes them in a list; and (c) a component that allows students to export a subset of identified promising ideas from the aggregate list to a new workspace for further inquiry. While the first component gives students the opportunity to practice promisingness evaluation individually, the second component brings judgments by all community members together, making promisingness judgments a collective endeavor in this community. The third component of exporting ideas for further inquiry gives life to this tool, engaging students in identifying promising ideas with a commitment to define new directions for their work, and providing them the opportunity to learn from their risk-taking by further exploring picked ideas. This tool itself is not complex, but pedagogical design around this tool could be rich. This research will explore pedagogical designs to promote students' capability in making promisingness judgments and eventually achieving more progress in knowledge advancement.

Settings and Participants

Research will be initiated at the Dr. Eric Jackman Institute for Child Study Laboratory School in Toronto, and gradually unfold at several other sites in Massachusetts, Columbia and Taiwan in the following two years. In the Institute for Child Study (ICS), knowledge-building discourse is integral to regular classroom activities, and K-6 classes have been committed to knowledge building pedagogy and use of Knowledge Forum for several years. This helps to establish an "optimal conditions" (Fischer & Bidell, 1997) to study the extent to which young students can make promisingness judgments in knowledge-building discourse. By collaborating with teachers, pedagogical designs that integrate promisingness evaluation to knowledge-building discourse will be iteratively tested in grade 3-6 in ICS. Iterations of design-based research will allow us to find ways to improve student capability in making promisingness evaluation as well as test whether promisingness evaluation can lead to greater knowledge advancement in their work.

To study the possible developmental trajectory of promisingness judgments, secondary school students from Gimnasio La Montaña in Columbia, college students from Smith College at Massachusetts and National Changqi University in Taiwan, and domain experts (graduate students from University of Toronto) will make promisingness judgments, as part of an embedded developmental study. These institutions

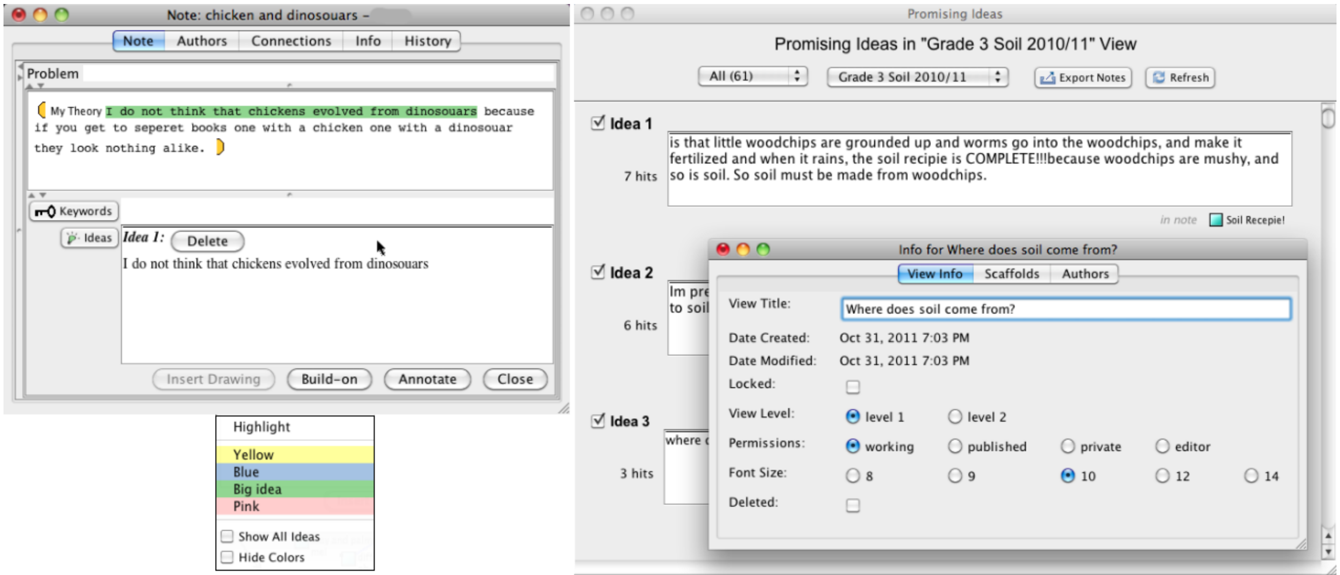

Figure 5. The Promising Ideas tool currently incorporates three components: (a) tag an idea—on the left, a student can identify an idea when reading a note, with a customizable categorization color scheme; (b) list tagged ideas—in the background window on the right side, all identified promising ideas from a view are listed; and (c) export selected ideas to a new view—users can then select a subset of ideas from this list and export them to a new view by the third component (the foreground window on the right).

have experience in knowledge building pedagogy and technology. Together with primary students at ICS, these participants will be asked to evaluate promisingness of a same set of ideas. Their responses, reaction time, and written or spoken predication will be analysed to find out how they perform differently in this task and through what processes—intuitive or rational thinking—are they making promisingness judgments. Results will be used to revise conceptual models of promisingness judgments, design principles of the Promising Ideas tool, and pedagogical design around the tool. When both the technology and pedagogy get mature enough, they will be tested in international sites mentioned above.

Data Sources and Approach to Analysis

For the design experiments with embedded developmental account of promisingness judgments, data sources will come mainly from classroom observations, students' online discourse in Knowledge Forum, and interviews and questionnaires. To evaluate impact of promisingness evaluation on student discourse, I will examine knowledge advancement achieved by students with the *scientificness* scales (Zhang et al., 2007). By coding student notes with the *ways of contributing* scheme (Chuy et al., 2011) and analyzing classroom conversations, possible influence of promisingness judgments on dynamics of student discourse will also be explored. Participants' promisingness judgments within the developmental framework of this study will be analyzed to test research questions related to the nature of promisingness judgments.

Significance

My research will encompass two significant gaps. Firstly, little empirical work exists that investigates the role promisingness judgments can play in student's knowledge work, although its importance has been highlighted by Bereiter and Scardamalia (1993) twenty years ago. Secondly, while there is an international effort to rethink on knowledge and skills that should be taught for the knowledge age, this research might broaden our understanding of 21st century skills by recognizing knowledge of promisingness as an important construct of knowledge creation.

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