Chapter # - will be assigend by editors

CREATING, CRISS-CROSSING, AND RISING ABOVE IDEA LANDSCAPES

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Abstract: Knowledge building/knowledge creation involves exploring idea landscapes, criss-crossing them in every direction to learn one's way around. Through pursuit of multiple and intersecting rather than prescribed paths, knowledge creators come to feel at home in a conceptual environment, able to pursue promising ideas, redirect work based on advances and failures, and adopt a "design thinking" mindset in which improving the conceptual environment is a realistic possibility. Such creative activity produces inventions, solutions to big societal problems, theories, cures, new business enterprises, and so on. It is the mainstay of success in what the OECD is terming an "innovation-driven" society. In contrast, schools tend to reduce the conceptual landscape through simplification of the range of ideas to be explored, paths to be pursued, and goals, leaving students to traverse a diminished space along fixed, common paths, with prescribed goals. School procedures leave little for design thinking to get hold of. The goal spanning Knowledge Building theory, pedagogy, and technology is to recreate schools as knowledge creating organizations--a formidable educational challenge requiring a shift in the modes of thought that since ancient times have characterized education. In this chapter we consider some of what this radical departure entails in terms of classroom practice and technology supports.

Key words: knowledge building, knowledge creation, idea landscapes, metadiscourse, design thinking, knowledge building technology

INTRODUCTION

Ludwig Wittgenstein in the preface to his *Philosophical Investigations* noted that the very nature of his investigations compelled "travel over a wide field of thought criss-cross in every direction." He said his thoughts were "soon crippled if I tried to force them on in any single direction against their natural inclination"; thus his work represented a "number of sketches of landscapes which were made in the course of these long and involved journeyings." Similar terms were used by Greeno (1991) in explaining something at the other extreme of the intellectual spectrum, children's acquisition of number sense. He called it "situated knowing in a conceptual domain" and likened it to learning one's way around in a city. Such learning is achieved, not by following a few prescribed paths but by criss-crossing the domain (of whole numbers or of intersecting streets) by numerous paths, until one comes to feel at home in the environment, to never be lost, and to be able to get from any one place to another by reasonably efficient means.[1] Human beings are not alone in performing this kind of learning. Woodworth (1958) called it "learning the environment" and found the clearest examples in maze learning by rats. Force the rat along a fixed path and it will learn that path but no other. Allow it to roam freely and it quickly learns the maze well enough that it can get to where it wants to go no matter where you place it. What sets humans apart is our ability to do this kind of "learning the environment" in non-physical environments—in conceptual or idea domains.

BEYOND LEARNING

Children learning their way around the domain of rational numbers are learning to deal with something that already exists. Wittgenstein, however, in criss-crossing the landscape of familiar philosophical and everyday ideas, was aiming to add to, transform, and rise above what was already there. His project was a creative one, even though it had much in common with and was based on "learning one's way around." He was going beyond learning to what is now popularly called "knowledge creation" (Nonaka & Takeuchi, 1995) or, in educational contexts, "knowledge building" (Bereiter & Scardamalia, 2014; Scardamalia & Bereiter, 1991). This is not learning with an added ingredient called "creativity." It is a creative activity in its own right. It is the kind of activity that produces inventions, solutions to big societal problems, theories, cures, new business enterprises, and so on. It is the mainstay of success in what the OECD is terming an "innovation-driven" society. Consequently, developing people able to carry on this kind of activity is a new imperative for education.

Going beyond learning to knowledge creation/knowledge building is not an additive process. It involves adopting a different mindset, a different mode of thinking: what is now coming to be called "design thinking" (Brown, 2009; Martin, 2009). Design thinking takes the kind of thinking professional designers do and extends it to other contexts. Design thinkers work with ill-defined problems, sometimes referred to as "wicked" problems (Rittel & Webber, 1973). The problems are open to different definitions and to tentative solution paths of unknown destination; and as work precedes the nature of the problem changes, so predetermined pathways will not suffice. Progress depends on pursuing promising ideas and redirecting work based on advances and failures.

The relation between learning and design thinking is a fluid one. Designers need to know their domains, and this involves the criss-crossing by multiple pathways that enables them to know their way around in the idea landscape. But they should not let habit take over and thinking follow only well-worn paths. The surest protection against this to maintain a design mindset throughout—to always be looking out for a better path, a better way of viewing the landscape, to allowing—as Wittgenstein did—the ideas to find their own paths rather than have directions forced upon them.

A design mindset and a willingness to tackle "wicked" problems encounter an unintended sort of opposition in schools. For reasons that are well justified from a practical standpoint, there is a strong tendency in schools to reduce things to fixed procedures. Even problem solving itself is liable to be reduced to a specified set of steps. Furthermore, much of the teacher's art lies in simplifying content so that it can be grasped by all the students with varying levels of background knowledge. Reduction to procedures and simplification of content together mean that the students are traversing a diminished conceptual landscape by fixed paths—the very opposite of what Wittgenstein described and what "learning the environment" entails. Routinized investigation of diminished domains means there is little for design thinking to get hold of.

There is an important kind of thinking being widely promoted in contemporary pedagogy. It is the kind of thinking involved in argumentation (Andriessen, Baker, & Suthers, 2003). We call this mode of thinking "justification mode."[2] It is concerned with evaluating, defending, and refuting knowledge claims (Driver, Newton, & Osborne, 2000). It is a different mode from the design mode of thinking, out of which novel knowledge claims arise. Bringing design thinking into mainline work with curriculum content is thus a radical departure from both the routinized procedures of "knowledge transmission" and the "justification mode" thinking that characterizes most of what is currently promoted as disciplinary thought.

Justification mode and design mode are both vitally important and found in all organizations. Any new idea needs justification before it can be rationally adopted or approved for further investment. But whereas an innovative organization might show a ratio of 90 percent design thinking to 10 percent justification, schools are more likely to show the reverse—or, in the case of core disciplinary subject matter, a ratio of 100 percent justification to zero percent design. In education settings, with their emphasis on getting ideas right, justification deserves a substantial place in students' thinking, but we would argue that for schools attuned to the knowledge age, a design mindset should be all-pervasive and productive design thinking ought to occupy more than half of activity in disciplinary courses. Does this mean less time for learning? No. Design thinking inevitably leads to learning related to whatever is being designed. If students are designing ideas in a conceptual domain (that is, producing explanations, theories, interpretations, and the like) then they inevitably learn domain content. There is no evidence of disadvantage in learning content knowledge, compared to more conventional approaches, and clear advantage in other cognitive outcomes (e.g., Chuy et al., 2010; Zhang, Scardamalia, Reeve, & Messina, 2009).

The societal need for design thinkers is evident both when the goal is innovation and when it is survival (Homer-Dixon, 2000). A conclusion pointed to by the preceding discussion is that producing design thinkers is a very formidable educational challenge, requiring a shift in the modes of thought that since ancient times have characterized education. It is not enough—may even be of no effect—to promote creativity as a character trait or skill. Design thinking needs to pervade the school experience, and this means bringing it into the heart of the curriculum, not leaving it as an occasional or extra-curricular activity. In the remainder of this chapter we consider what such a radical departure entails in terms of classroom practice and what supports technology may provide for it.

STUDENT RESPONSIBILITY FOR IDEA IMPROVEMENT

It is now generally recognized that students are not blank slates when they enter a new area of subject matter. They already have beliefs and dispositions to think in certain ways about the ideas presented. Sometimes these prior beliefs and dispositions stand in the way of grasping and internalizing what is taught; a whole field of research has grown up around issues of conceptual change (e.g. Vosniadou, 2013). More generally, the expectation is that in all areas students will leave school with better ideas than they brought in with them. But the responsibility for bringing about this idea improvement is mainly assigned to the teacher, with the student expected to cooperate. This means that the teacher is the one who does whatever design thinking goes into idea improvement. That generalization seems to hold not only for "instructivist" approaches, where the teacher's responsibility is taken for granted, but also for most "constructivist" approaches. In these approaches, variously termed "inquiry" or "problem-based" or "project-based" learning, idea development is viewed as coming about through students' own constructive thought, but *responsibility* for making it happen remains with the teacher. Yet idea improvement is a driving force in design thinking of all kinds. If students are to develop into design thinkers, able to go beyond received notions, school ought to be a place where they gradually take on the responsibility for idea improvement in their own intellectual development.

Knowledge Building[3] is an educational approach focused on collective student responsibility for knowledge advancement and idea improvement (Scardamalia, 2002; Scardamalia & Bereiter, 2003, 2014a). Working to improve one's ideas about the world is a challenge to both intellect and character. In the normal course of life, idea improvement is failure-driven; it takes place when something malfunctions, falls short of its goal, or upsets our expectations. Scientific beliefs, social beliefs, moral beliefs, and so on are seldom perceived as having failed, and so the basic motivation for idea improvement is weak. It needs support. Teachers can provide support, but need to resist taking on the responsibility for idea improvement; instead, their task is to help the students take on such responsibility. The other major kind of support is peer support. That is why Knowledge Building emphasizes *collective* responsibility and establishing communities in which idea improvement becomes the norm—a norm that both students and teachers help maintain. The proposition that all ideas are improvable serves in Knowledge Building as a working assumption. It isn't always true. There are unimprovable ideas, sometimes because they are hopelessly imperfect, but more often because they are vacuous. But as a working assumption it not only gives students license to criticize received ideas (most thinking-oriented approaches do that) but it also conveys the challenge to produce a better idea and suggests that, rather than summarily rejecting a faulty idea, they should try to build on whatever merits the idea has and, like software designers, produce a new and improved version.

FROM TEACHING FOR UNDERSTANDING TO KNOWLEDGE BUILDING

"Teaching for Understanding" is a banner behind which march hundreds of thousands of reform-minded educators,[4] especially those with connections to the learning sciences or mathematics and science education. Besides being valued in its own right (all the great philosophies and religions pursue it), understanding is also implicated in all sorts of other educational issues. Understanding aids memory and recall, enabling us to reconstruct knowledge we have partly forgotten. It plays an important role in transfer of learning to new situations (Bereiter, 1995). It provides a basis for productive analogies and comparisons. And, in the form of "principled practical knowledge," it grows out of and enables the solution of design problems (Bereiter, 2013).

No one, of course, is opposed to teaching for understanding, but the need to take it more seriously was brought home to educators by mounting evidence over the past 20 years of failures of students to learn with understanding. As we have said before, it appears that we are sending large numbers of students forth into the so-called Knowledge Age with preNewtonian physics, preDarwinian biology, and preSmithian economics. In recent decades, attention has become focused on the "big ideas" that underlie and give coherence to whole fields of study. Examples are the idea of force in Newtonian physics, natural selection in evolutionary theory, and market in economics. Without understanding of these ideas, the study of their associated disciplines tends to be rote, regardless of teachers' efforts to enliven it with projects, experiments, problems, and debates.

Teaching for understanding and knowledge building are closely related, but not the same. There are other ways than knowledge building to teach for understanding; for example, lecture-demonstrations, can be effective provided the students are actively trying to understand what is being taught. By the same token, knowledge building in education has purposes that extend beyond understanding—for instance, democratization of knowledge, idea diversity, and socializing students into a knowledge-creating culture (Scardamalia, 2002). Solving authentic problems of understanding is a major concern of knowledge building across the whole educational spectrum. Consequently the widespread interest in teaching for understanding can serve as the entering wedge for bringing knowledge building into formal education. The point we want to argue in this chapter, however, is that design thinking constitutes a powerful way and probably the most powerful way to pursue understanding. The philosopher Karl Popper made this point in talking about understanding a theory:

> What I suggest is that we can grasp a theory only by trying to reinvent it or to reconstruct it, and by trying out, with the help of our imagination, all the consequences of the theory which seem to us to be interesting and important. . . . One could say that the process of understanding and the process of the actual production or discovery of... [theories, etc.] are very much alike. Both are making and matching processes. (Popper & Eccles, 1977, p. 461)

Popper has here described what some educators would characterize as "active learning." However, it is a very distinctive (and uncommon) sort of activity that could better be characterized as constructing a theory that is heavily dependent on an existing theory. It is an effort that aspires earnestly to coherence with relevant facts—facts about the world and facts about the theory in question. It is design thinking enlisted in the service of achieving understanding, and it represents Knowledge Building in an exemplary form.

Both teachers and technology can help students accomplish high-level knowledge building of this kind. For teachers, a leap of faith is required: They must believe that students can and should take the initiative in constructing a theory-like understanding of the world and in improving their own ideas. That is the leap that will vault teachers beyond lecturing, Socratic questioning, guided discovery, and the many other common approaches to teaching for understanding.

TEACHERS BECOMING KNOWLEDGE CREATORS

In order for teachers to help students become knowledge creators, they themselves need to have experience in knowledge creation. Ideally, a school faculty will function as a knowledge-building community, working to advance the state of the art in teaching at both conceptual and practical levels. But at a minimum, pre-service teacher education should engage future teachers in a lively knowledge-building community. This should be a community that goes beyond the normal concerns with learning about educational theories and practices and developing teaching skills. It would be a knowledge-building community with design thinking applied to all the aspects of the world—scientific, social, moral, esthetic, and so on that teachers must attend to in their work—with idea improvement as the norm that they seek to establish in their own classrooms. Teachers, therefore, need to live in such communities themselves in order to be able to promote design-mode work with ideas by their students. Inasmuch as this is not something that will have been familiar to teacher candidates from their own school experience, preservice education ought to immerse them in it. In short, knowledge building should not just be something that teacher candidates learn about and receive instruction in how to teach; it should characterize their experience in teacher education.

Teachers themselves typically do a lot of work in design mode, but it is designing activities and lessons. It is not working in design mode with ideas. Both in teacher education and in subsequent professional meetings and workshops, ideas are dealt with in traditional justification-mode fashion. They are things to argue about, criticize or advocate; they are not things to improve or reconstruct. Therefore the much-bemoaned split between theory and practice is thoroughly institutionalized. Efforts may be made to “translate theory into practice,” but in an intellectually alive profession there ought to be comparable efforts to “translate practice into theory” and a continual two-way interaction, with Knowledge Building a way of life for teachers as well as students. This requires sustained, connected dialogue among teachers with *idea improvement* a guiding purpose.

TECHNOLOGY TO HELP STUDENTS TAKE RESPONSIBILITY FOR IDEA IMPROVEMENT

There is an abundance of digital technology available that can help students grasp ideas (through simulations and games, for instance), argue about ideas, and represent ideas in communicable form. All of these can play useful roles in Knowledge Building, but they do little to help students with what we have pointed to as the essence of creative knowledge work in modern times: students taking collective responsibility for idea improvement. This is not something that comes naturally to people, the way curiosity and argumentation do. Social support is needed. A classroom norm of continual idea improvement needs to be established, and with this goes a willingness to collaborate in advancing ideas as a public good and not only a personal good. Working to improve and not merely evaluate ideas means working with ideas in design mode, and this too is something that does not come naturally or without effort. Yet we have seen schools where even the youngest children engage in design thinking with ideas as if they were born to it. These are classrooms where creative idea development has become a way of life, a satisfying though continuously challenging way of life—just as it is in the world's leading centers of research and innovation. There is good reason to believe, based on comparison of these successful Knowledge Building classrooms with more conventional but still inquiry-based classrooms, that technology plays a significant role.

What kind of technology can support knowledge building and the forms of discourse that serve to create new knowledge? We have been working at developing, testing, and refining such technology for more than 30 years, starting with what has been recognized as the first networked collaborative learning environment, which we prototyped in 1983.[5] Originally titled CSILE (Computer-Supported Intentional Learning Environment), it was rebuilt a decade later as Knowledge Forum (Scardamalia, 2004), which is the name it still bears after numerous version changes that moved it from a client-server architecture to being fully web-based. Supporting knowledge building discourse has been the goal from the beginning. The basic ways of doing this have been the use of simple, customizable, non-scripted discourse supports (my theory…, a better theory is…., putting our knowledge together…), and a graphical interface where notes representing ideas can be organized and reorganized against backgrounds that represent higher-level conceptual structures. Knowledge Forum developers continue to work on providing further kinds of support, guided by design principles such as the following (from Scardamalia, 2003):

1. Support for self-organization that goes beyond division of labor.
2. Shared, user-configured design spaces that represent collective knowledge advances built from the contributions of team members.
3. Support for citing and referencing one another's work so that contributions to the evolution of ideas are evident and can become objects of discourse in their own right, much as is the case in the history of thought.
4. Ways to represent higher-order organizations of ideas and to signal the rising status for improved ideas as contrasted with their nondescript entry in threads, folders, and repositories where they are lost amid information glut.
5. Ways for the same idea to be worked with in varied and multiple contexts and to appear in different higher-order organizations of knowledge.
6. Systems of feedback to enhance self- and group-monitoring of ongoing processes and to tap idea potential—as distinguished from assessment and management tools used exclusively for filing, organization, and end-of-work or external evaluation.

One of the concerns teachers raise in using Knowledge Forum is that students contribute such a quantity of diverse ideas that the conceptual landscapes (as represented by note icons on the graphical views) become messy and over-crowded. We have resisted the traditional educational "solution"—to cluster or categorize ideas. Such categorization is frequently referred to as "finding big ideas," but we have yet to see the process leading to big ideas. Instead ideas are organized by topics, with some ideas dropped because they do not fit, some arbitrarily moved to one category because the method precludes representation in multiple categories, and some added to categories arbitrarily.

We are working instead toward technology that supports criss-crossing and rising above idea landscapes. Knowledge Building research has entered an intense phase focused on formative feedback and metadiscourse—components of the criss-crossing landscapes idea. This requires building tools to allow students to traverse the landscape of their ideas from multiple perspectives. Thus for example, their ideas can be visualized from the point of view of discourse moves represented in them, or on the basis of student-identified promising ideas, or semantic overlap with other knowledge resources (such as curriculum guidelines) to identify commonalities and differences. Research pertaining to each of these has been published (Scardamalia & Bereiter, 2014a; Resendes, Scardamalia, Bereiter, & Chen, in press; Chen, Scardamalia, Resendes, Chuy, & Bereiter, 2012) so we do not go into detail here.

These publications report a number of technological innovations that have all had significant positive effects on students' knowledge building. Students and teachers see aspects of their work that are new to them, and from these new perspectives set a new course for their discourse. For example, students as young as 7 years of age noted that they had many theories but no evidence for them; they self-organized into new teams to determine if there is any evidence for theories they consider important. Through use of another visualization they saw words in curriculum guidelines that they never used; they undertook spontaneously to investigate the missing terms and to incorporate the related concepts into their work. Another study, conducted with children a year older, showed that when students saw ideas they judged to be promising they made selections to drive their discourse forward (Chen, et al., 2012).

The landscapes of ideas represented by Knowledge Forum views are populated mainly with students' own ideas, in the form of notes, although these notes often cite ideas drawn from outside sources, and content from outside sources may also be brought into the view landscape to be worked on along with the students' own productions. We envision students and teachers as collaborative designers of idea landscapes, with tools for criss-crossing these landscapes and viewing them from different perspectives. Achieving this involves fascinating design issues, which an international design lab is forming to pursue. New technologies for semantic and social network analysis and for diverse kinds of learning analytics are being incorporated into the new designs. The challenge here, as it has been from the earliest days of CSILE development, is to ensure that the technology supports higher levels of agency rather than the technology itself taking over the higher-level processes (Scardamalia & Bereiter, 1991). The more powerful the technology, the more vigilance is required to keep cognitive responsibility in the hands of the students (Scardamalia & Bereiter, 2014b). This means making the technology transparent, avoiding "black box" kinds of analysis as much as possible, and having students make their own connections and find their own paths through the idea landscape. An important further challenge for the international design lab is expanding the knowledge-building communities in which students work. Education is outgrowing the classroom in many ways. Drawing information from outside the classroom is something that web-enabled classrooms and web-enabled students already do. But bringing students fully into the Knowledge Age requires more than this. Students need not only to avail themselves of the knowledge advances being made in the larger world of knowledge creation, they need in some legitimate sense to feel themselves part of that larger knowledge-creating world. It is not clear how technology can bring that about. The present-day “social web” (also known as Web 2.0) is hardly a model for that, although it provides promising tools.

WHAT IS POSSIBLE?

Learning one’s way around in a conceptual domain by criss-crossing it in multiple unspecified ways, letting ideas follow their “natural inclination,” as Wittgenstein put it, and rising above the “landscape” of ideas to contemplate the possibility of new, more powerfully integrated ideas: These represent a quintessentially systemic approach to education. Self-organization and emergence rather than instruction and guided practice are its dynamic elements (Bereiter & Scardamalia, 2013). We are well aware of the opposition to such “minimally guided” education and of the strong evidence on which this opposition is based (cf. Kirschner, Sweller, & Clark, 2006). Prominent current approaches to more guided instruction provide guidance via scripts (Weinberger, Ertl, Fischer, & Mandl, 2005) or use learning analytics to prescribe instruction (Dietz-Uhler &Hurn, 2013). Although these approaches are typically directed toward pre-specified learning objectives and paths toward attaining them, they are adaptable enough that one can imagine a “criss-crossing the domain” script. The question raised by Knowledge Building research is whether such stronger guidance is needed or desirable. The studies cited in the preceding section suggest that when young students are equipped with appropriate tools they can take on considerable responsibility and can explore conceptual domains productively on their own initiative. The argument we have been making here is that this is a better way to initiate students into a world where design thinking is the norm and where sustained creative work with ideas is paramount.

Knowledge Building is part of a long-term trend toward making knowledge itself an object of deliberate, design-oriented work. Schooling may lag behind that trend, but it cannot ultimately resist it. The profound changes that will eventually bring education into the Knowledge Age are not likely to come in response to outside pressures or new regulations. They will come about as the whole society—including teachers, parents, and policy-makers—begins to internalize and feel comfortable with the idea of creating and working with knowledge. As knowledge creation becomes increasingly familiar in various walks of life, it will become easier to grasp as an educational approach, and easier to distinguish from methods which only mimic its surface features. How long it will take for this to happen, we cannot say. However, we think it is safe to say that educators can speed up or retard the process.

Although Knowledge Building is working well and producing impressive results in a number of different settings (e.g., Chan, 2010; Scardamalia & Egnatoff, 2010), and school-government-university partnerships are advancing it (Laferrière, Breuleux, Allaire, Hamel, Law, Montané, Hernandez, Turcotte, and Scardamalia, in press), it is clearly a work in progress as far as wide-ranging efficacy and full-scale implementation are concerned. A key concept in creative enterprises of all kinds is "promisingness." Creative design—whether it is producing a poem, a theory, or an educational innovation—always takes place in a context of uncertainty about outcomes, and thus requires a willingness to judge what directions of movement hold promise and justify further investment. That is the claim we would make about the educational approach discussed here. It is abundantly promising, especially in terms of the emerging needs of innovation-driven, problem-solving societies.

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[1] At a higher educational level, Spiro and colleagues (1987, 1990) use Wittgenstein's "criss-crossed landscape" metaphor to characterize challenges for university-level case-based work that aims to extend these cases so that they mirror real world complexity.
[2] In an earlier formulation (Bereiter & Scardamalia, 2003), we used the terms "belief mode" and "design mode," and these terms have appeared in many of our writings and presentations since. However, we found that educators tend to equate belief mode with accepting and transmitting beliefs based on faith or authority, so that by implication design mode became equated with reliance on evidence. This totally misses the point of the distinction and assimilates it into a conventional good-bad polarization that is crippling to educational thought. Hopefully, replacing "belief" with "justification" gets rid of the false polarity and allows educators to see the virtues of both modes and their interdependence.
[3] Because the term "knowledge building" now appears in many documents, often without definition, we use lower case with the generic term and capitalize Knowledge Building when referring to the approach originating in our laboratory and promoted by organizations such as Knowledge Building International.
[4] As of April, 2015, there were 264,000 Google references to this phrase. Figuring that there are 10 sympathizers for every web publisher, the estimate of hundreds of thousands might well be increased to millions.
[5] This was recognized in a career achievement award to the present authors at the 2005 CSCL conference.

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