Bereiter, C. & Scardamalia, M. (2014). Knowledge building and knowledge creation: One concept, two hills to climb. In S. C. Tan, H. J. So, J. Yeo (Eds.) *Knowledge creation in education* (pp. 35-52). Singapore: Springer.

Chapter 3

Knowledge Building and Knowledge Creation: One Concept, Two Hills to Climb

Carl Bereiter and Marlene Scardamalia

Early in the 1990s, the term "knowledge creation" appeared in the organizational sciences literature, conveying the idea that companies can not only accumulate and use but literally create knowledge that enables them to progress (Nonaka 1991; Nonaka and Takeuchi 1995). At about the same time, the term "knowledge building" appeared in the learning sciences literature, representing the same idea (Scardamalia and Bereiter 1991; Scardamalia et al. 1994). The core idea is suggested by the conjunction of the two key words, "creation" and "building": Knowledge is the product of purposeful acts of creation and comes about through building up a structure of ideas (for instance, a design, a theory, or the solution of a thorny problem) out of simpler ideas. Nonaka called the process "combining," which though true scarcely does justice to its complexity. (That is like saying Shakespeare wrote his sonnets by combining words.) In later decades the self-organizing character of knowledge creation/knowledge building was to become better appreciated (Bereiter and Scardamalia 2013; Li and Kettinger 2006), but its recognition as purposeful action persists.

Educators were already familiar with the concept of constructivism, more accurately termed "psychological constructivism," as represented in the expression "learners create their own knowledge." Mainly based on the research of Piaget and his school, this version of knowledge construction is an internal process, usually taking place spontaneously and without awareness. Children building up a cognitive structure that recognizes conservation of number under rearrangements of tokens do not know that is what they are doing and are not purposefully striving to achieve it. Knowledge creation/knowledge building is, in strong contrast, a type of deliberate, conscious action, which produces knowledge that has a public life. This is not to discount chance discoveries, insight, and the importance of internal cognitive activity in knowledge creation. It is, rather, to emphasize that the products of knowledge creation are public ideas and artifacts embodying them and that their production is an overt activity that can within limits be planned, guided, motivated, and evaluated much like any other kind of work. As Lindkvist and Bengtsson (2009, Abstract) put it, "Once created, such knowledge is seen as having something of a life of its own, pregnant with possibilities for further development and use – to be explored collaboratively – in ways which are unimaginable and unfathomable." It is this kind of overt collaborative activity that knowledge managers promote in the workplace and that we have tried to promote in education.

Knowledge creation/knowledge building may be considered to take place in a problem space—a conceptual space that contains goal states, intermediate states, constraints, and possible moves (Newell 1980). We suggest that in practice the problem space for knowledge building is larger and more complex than the problem space for knowledge creation. It contains a wider range of goal states. Whereas the scope of corporate knowledge creation tends to be limited by the nature of the organization's business, educational knowledge building has the whole world of human knowledge as its intellectual workspace. Knowledge creation in the corporate sector often consists of coming up with a promising idea or concept, which is then passed on for development to other groups within the organization, whereas knowledge builders in educational settings are generally expected to do the development themselves. "Ideas are the easy part," says creative design group Fahrenheit 212 (2009). This is as true in schools as it is in businesses. Knowledge building is very much concerned with "the hard part." Idea improvement is a core knowledge building principle. Knowledge building as an educational approach is fundamentally an idea improvement challenge; it is students taking collective responsibility for improving their ideas rather than leaving this as a task for the teacher.

Because knowledge creation and knowledge building have developed as separate research programs based on the same or related concepts, there is potential for the two research programs and the communities of practice growing out of them to learn from each other. Paavola and Hakkarainen (2005) and Chan (2013) have examined the shared conceptual basis, mainly from the standpoint of what education could learn. As part of a Canadian "Initiative on the New Economy," we launched a project intended to investigate knowledge building practices in both schools and adult places of creative knowledge work. However, a wave of militant anti-corporatism at our home institution made it necessary to abandon the "knowledge work" part of the project. European researchers were more fortunate, launching "KP-Lab," which did successfully carry out studies on knowledge practices in both the educational and the corporate world (Moen et al. 2012). But it is probably fair to say that the potential for cross-fertilization has yet to be fully exploited and that the obstacles to doing so are more attitudinal than scientific.

Distinctions That Matter

The idea of knowledge creation caught on easily among innovation-minded business and government people. In education, knowledge building similarly received a friendly reception. However, the semantic proximity of "knowledge building" to such more familiar terms as "constructivist learning" and "inquiry learning" made it difficult for many educators to see what was distinctive about this particular kind of constructivist and inquiry-oriented activity.[1] This view of

[1] Interestingly, critics of constructivist learning practices seem to have grasped the distinction, arguing that the problem space of learning and the problem space of knowledge production are not the same (Kirschner et al. 2006; Mayer 2004). We agree

knowledge building essentially obliterates the idea of students engaging in actual knowledge creation, in the sense that that term is used outside of educational settings. Yet that is precisely what "knowledge building" is intended to imply. In Phillips' (1995) multidimensional classification of constructivist viewpoints, one of the dimensions has "individual psychology" at one end and "public discipline" at the other. Knowledge building and knowledge creation, as we use the terms here, are far out on the "public discipline" end of this dimension. Although individual psychology is relevant to any practical approach to knowledge creation, the history of science and the history of ideas often recount important instances of knowledge creation (e.g., Watson 2005), without reference to the psychology of the actors involved. This is most obviously in the case of achievements of the distant past—invention of writing or the wheel, for instance—of which there is no historical record on which to base a psychological explanation.

A distinction between knowledge creation/knowledge building and learning is obvious in work settings: Except in special circumstances, people are paid to produce, not to learn. The distinction is worth making in educational activities as well, however. It allows us to distinguish activities whose sole value is in what they do for the learner from activities that have some larger epistemic value such as advancing the state of knowledge in a community. Just as research advances the state of knowledge in a discipline or in a corporation, it is possible for research, theorizing, and creative knowledge representation to advance the state of knowledge in a classroom community. Knowledge building, as an educational approach, focuses on the advancement of community knowledge, with individual learning as a by-product (Scardamalia & Bereiter, 2006, in press).[2] Students assume collective responsibility for advances in community knowledge, with support for taking charge at the highest levels, including problem definition, goal setting, monitoring advances, setting work on to a new and unexpected course, and so forth. Those are all part of knowledge creation as a cultural practice. Because many other educational approaches do not engage students in this manner, although they are similar to knowledge building in being "constructivist" and

---

that a distinction needs to be made. It cannot be assumed that knowledge creation/knowledge building is going on just because learning is taking place through constructivist activities such as inquiry and guided discovery. And it is equally a mistake to infer that because community knowledge is advancing, individual learning for all students is progressing with it. Individual learning needs to be verified independently of the work that brings it about.

[2] There is nothing unusual about learning being a by-product. That is how learning comes about in most of our daily experience and also how it comes about in most kinds of schoolwork, including activity and play-based methods and even such traditional schoolwork as worksheet exercises, assigned problems, and course papers. The exceptions are approaches in which learning is the explicit goal on which classroom strategies are focused. They include direct instruction (Gersten et al. 1987) on one side of the methodological spectrum and on the other side what is called "intentional learning" (Bereiter and Scardamalia 1989) or "intentional cognitive change" (Sinatra and Pintrich 2003), in which students themselves pursue learning strategically.

involving "inquiry," the distinction between knowledge creation/knowledge building and learning is important for any in-depth description of contemporary approaches to education.

Paavola and Hakkarainen (2005) called knowledge creation a metaphor. In our view there is nothing metaphorical about it (except in the sense that all abstract terms have metaphorical roots). In a given dialogue, knowledge is either literally created or it is not, although determining which is the case is often difficult, especially with the sketchy evidence provided by records of student discourse. Computerized text analysis holds promise of making assessment of group cognition more tractable (Rosé et al. 2008) and seems likely to figure in the next wave of research on knowledge building/knowledge creation.

We believe knowledge building research and development need to distinguish between what we have termed "belief mode"[3] and "design mode" in work with ideas (Bereiter and Scardamalia 2003). Belief mode comprises all kinds of activities that are concerned with evaluating, questioning, accepting, or rejecting knowledge claims. Design mode comprises a broad range of activities concerned with knowledge production and improvement: theorizing, invention, design, identifying promising ideas, abd searching for a better way—in short, all the kinds of activities that mark a knowledge-creating organization. The distinction is blurred, however, in the writings of Nonaka and his collaborators. This is probably not so important for innovative work in organizations, where design mode clearly prevails. In education, however, classroom work with ideas, whether employing traditional didactic or modern enquiry methods, is almost exclusively carried out in belief mode, as it has been for millennia. Bringing design mode activity into disciplinary study, which in an operational sense is what knowledge building in the schools is about, therefore needs a higher degree of conceptual clarity than may be required in most knowledge work settings. Furthermore, education must give serious thought to issues of epistemic agency, to the gradual transfer to students of the kinds of epistemic responsibilities traditionally reserved for the teacher: formulating knowledge

---

[3] The term "belief mode" is derived from the traditional definition of knowledge as "true and justified belief," and thus is very broad in scope. However, we have encountered two misunderstandings that undermine the point of the distinction: Some equate belief mode with rote as opposed to meaningful (or constructivist) learning; but attaining "true and justified belief" requires meaningful learning. Even the most authoritarian teaching in belief mode presumes something beyond rote memorization of word strings. Others equate "belief" with faith-based or authority-based knowledge, seeing it at odds with more reflective and critical bases of knowledge that "justified belief" is intended to include. Belief mode encompasses everything from dogmatic proclamation and indoctrination on one hand to the most reflective and skeptical thinking on the other hand. We have tried alternative terms including "proposition mode," and "argument mode," which avoid some misconceptions but promote others; so we remain with "belief mode" as the technically most accurate term. It is well to keep in mind that the wisdom of the past, whatever its source, comes down to us in belief mode, and it is in that mode that we interpret, argue about, and evaluate it. The paradigm of active work in belief mode is, in Western civilization at least, Socrates, whose method of questioning tested the limits of how far one can progress toward knowledge solely by working in belief mode.

goals, identifying problems and difficulties, assessing knowledge progress, revising questions, revising strategies, and bolstering intellectual engagement and equality of opportunity. Workplace managers may make decisions about epistemic agency on a purely pragmatic basis, but teachers must look ahead to the long-range benefit of the students. Studying knowledge-creating discourse, bringing sustained creative work with ideas into the curriculum mainstream, and promoting epistemic agency sensibly together make up a research agenda that we hope the new generation of learning scientists will carry forward, aided by the new tools and new scientific knowledge rapidly coming available.

The "Design Thinking" Mindset

Closely related to the concept of design mode is a concept rapidly gaining traction in knowledge management circles: "design thinking" (Martin 2009). In simplest terms, it means taking the kind of thinking that goes on in design labs and applying it to the full range of problems that require thought. It is the kind of thinking that characterizes working in design mode. Some writers treat design thinking as a methodology, comparable to "design-based research" in the learning sciences. Many others, however, treat it as a mindset, a way of thinking that becomes habitual and not something to be turned on only for certain purposes. This way of regarding design thinking is especially appropriate for knowledge building in schools. Instead of "doing" knowledge building in selected subjects at selected times, students should always be alert to the possibility of better ideas, better explanations, better ways of doing things, never quite satisfied with final answers, always looking for opportunities to design and redesign and to act on the basis of well-constructed ideas and understandings. A design thinking mindset, if reinforced through years of experience, should be something they carry with them into adult life. It would serve them in life's daily challenges and in whatever occupations they enter. It could be the most important thing they get out of school.

Unlike a belief mode mindset, a design mindset is inherently social. A surprisingly number of bloggers identify empathy as an essential part of it. When community members value idea improvement and see idea diversity as a source of energy for the enterprise, they are more appreciative of the diverse ideas of group members. They build on, find new syntheses, explore authoritative sources, and find problems with current explanations. When this becomes part of the classroom ethos, not dependent of the proclivity of a few students or the teacher, a new norm is established. Students simultaneously help each other and request more of each other. There is excitement in discovery, but almost as soon as a discovery is celebrated, someone notes the next thing to be understood—the challenge beyond where they are at present. This is not experienced as defeat but as the very thing that makes a journey of discovery a journey. Students are not working independently on their own or group projects, although they may be working on their individual contributions to a common enterprise. The idea diversity that comes from their different contributions advances the collective state of the art in their community.

Epistemology of Knowledge Creation/Knowledge Building

In recent decades epistemology has moved beyond its traditional concern with the evaluation of truth claims to a concern with how novel claims come about—hence, with knowledge creation or what philosophers refer to as the logic of discovery (Nickles 1980). Research on students' epistemologies, however, has largely remained locked into epistemology's traditional concerns and thus with issues such as relativism, authority, and certainty. Taken in its largest sense, Piaget's "genetic epistemology" is a wide-ranging epistemology of knowledge creation, but in the simplified version that prevails in education and child development it scarcely addresses knowledge creation at all. Can the epistemological side of Piaget's theory of knowledge be made accessible to educators? A workable theory of knowledge is needed to help both educators and students deal with what Piaget (1971) saw as epistemology's main challenge: "How can one attain to something new?"

From an intellectual standpoint, the relevance of epistemology to knowledge building/knowledge creation is obvious. If we are in the business of creating knowledge or educating other people to create knowledge, we ought to know something about this stuff we are supposedly creating (including knowing whether it is admissible to call knowledge "stuff" or whether such reification starts us off down a wrong path). From a cognitive point of view, whatever functions as knowledge is knowledge. This view had a practical consequence in the design of expert systems, which sought, for instance, to embody the knowledge—both explicit and tacit—of expert medical diagnosticians in a database where it could be used in computer programs to perform diagnoses or train students This broadened conception of knowledge is one within which equally broad theories of knowledge creation may be developed.

Polanyi's (1966) concept of "tacit knowledge" has a central role in Nonaka's theory of knowledge creation, which posits a cyclical process by which tacit knowledge is made explicit, combined with other explicit knowledge to produce new knowledge, which is then assimilated into tacit knowledge to start a new cycle of transformations. Polanyi (1966) characterized tacit knowledge by the maxim "we know more than we can tell"—examples being skills and intuitive understandings. Lindkvist (2005) has pointed out, however, that we can also "tell more than we can know"—examples being conjectures, hypotheses, models, thought experiments, and design concepts, which are in the nature of potential rather than actual knowledge. This part of knowledge creation is not well developed in the work of Nonaka and his collaborators, leading some to assert that Nonaka does not really have a theory of knowledge creation (e.g., Gourlay 2006; Tsoukas 2009). There are, however, alternatives models: models based on complexity theory, which treats knowledge as an emergent of self-organizing processes (Li and Kettinger 2006); models incorporating Popper's (1972) concept of "world 3," which treats knowledge as having a sort of external, object-like existence (Gourlay 2006; Lindkvist and Bengtsson 2009); and models based on studies of dialogue and which recognize it not only as a medium but as a driver of concept creation and revision (Tsoukas 2009). Our own efforts to develop a theoretical basis for knowledge creation incorporate all of these alternative conceptions, which happen to be highly compatible (Scardamalia and Bereiter in press).

In education it is common to think of knowledge as a psychological state—as something in the individual brain. However, there is knowledge such as that possessed by an expert surgical or sports team that can only be described at the group level (Stahl 2006). There is yet a third way of characterizing knowledge, which is implied by terms such as "intellectual property" and "state of the art." This is knowledge that is not embodied in any particular individuals, groups, or documents, but that has a sort of life of its own (cf. Popper 1972). Knowledge-building theory, as we have developed it, is more in harmony with this third conception of knowledge than with Nonaka's more mentalistic model, with its emphasis on tacit knowledge. There is no denying the importance of tacit knowledge, but we see it as belonging more to a theory of knowledge mobilization (Levin 2011) than a theory of knowledge creation.

Knowledge Building Communities and Technologies

The products of knowledge building/knowledge creation can be understood as advances in the collective state of knowledge. It must be emphasized that these are advances in the Popperian type of knowledge referred to above—amounting to the creation of intellectual property or something analogous to it—and different from an advance in what people individually know. Individuals will learn in the process of advancing community knowledge, of course, and this will happen in any situation, not just in educational situations, but this learning is a by-product that needs to be evaluated separately from the collective knowledge advances. Collective advances may take the form of theories (explanations of the previously unexplained), inventions, problem solutions, and a variety of types of knowledge that add to the capabilities of the community, including especially its capabilities for further knowledge advances. Individual talents, imaginativeness, and curiosity and cognitive skill necessarily play a part, but the knowledge creation itself is a collective phenomenon affected by such group-level characteristics as morale, norms, and community goals.

In order for knowledge building to succeed among students and others new to the process, both social and technological supports are needed. Two major kinds of innovation are required to provide such support:

(a) *Social innovation: transforming school classes into knowledge building communities.* Every well functioning school class is a community of some sort, but there are differences in the kind of function the class is organized around. Some are organized around the performance of schoolwork—completing assigned work in a timely and responsible manner. Some are organized around learning—advances in individual achievement related to specified knowledge and skill objectives. Knowledge-building communities are, as indicated previously, organized around the creation and improvement of community knowledge. Functioning as a knowledge-building community means not only that the main work of the class is knowledge building but that students identify themselves as a group dedicated to advancing the state of knowledge and develop norms and practices and a team spirit that supports collaborative knowledge building and that they socialize new students (and sometimes new teachers) into the community and its values and practices. Creating such a cohesive community is something to which knowledge-building teachers devote considerable effort, because it pays big dividends in enabling students to take over more and higher levels of responsibility.

(b) *Technology innovation: knowledge-building technology*. Although knowledge creation/knowledge building can go on without technological assistance—and often does in adult knowledge work—technology can provide a number of supports that could be helpful in many work contexts but that have proved essential in enabling school students to carry through efforts at knowledge creation. Knowledge Forum® is a web-based environment in which knowledge-building discourse is supported through the use of multimedia notes entered into graphical views, where they can be linked, commented on, and subsumed by higher-level syntheses (Scardamalia and Bereiter 2006). Knowledge-building discourse is "scaffolded" by user-selected epistemic markers customized to support theory building and other forms of idea-centered discourse. Teachers who have tried to implement knowledge building without a supportive digital environment have simulated these environments with lower-tech devices such as sticky notes and pockets on a bulletin board. This demonstrates that, valuable as oral discussion may be in creative work with ideas, something beyond it is required in order to keep students' ideas alive as objects of inquiry.

The technology design challenge is to produce more powerful supports for creative work with ideas while keeping agency in the hands of the students rather than micromanaging the process the way "scripts" are prone to do (cf. Dillenbourg 2002). There are now many ways of representing and communicating content digitally that go beyond asynchronous written communication. There are also network and semantic analysis technologies that can provide meaningful feedback to people engaged in collaborative knowledge work. The hoped-for result is greater and more varied interaction among students and between students and ideas, facilitating self-organization at both social and conceptual levels, along with better-informed metacognitive control of knowledge processes. Effective designs need to overcome the danger of loss of continuity—separate and only loosely connected discourses scattered across wikis, blogs, text messages, online forums and appearing on a variety of devices—and black-box intelligent technologies taking over thinking that students should be doing for themselves. In a redesign and rebuilding of Knowledge Forum that is currently in progress, we are striving to support inputs from a variety of sources coming together into a coherent discourse. We are also opting for feedback technologies that are maximally transparent to users and that favor emergence of new ideas (Scardamalia and Bereiter in press).

Authentic Knowledge Creation by Students?

One of the ironies of knowledge creation in schools is that it tends to be judged against the standard of historically recognized geniuses (and therefore found lacking), while out in the world knowledge creation is judged according to whether it constitutes an advance over what has gone before. Authentic knowledge creation can range from tiny increments to world-changing discoveries and inventions. What students produce ought to be credited as authentic knowledge creation so long as it falls somewhere in that large range. Our experience assures us that students from the youngest years of schooling on can operate in design mode—typically producing small increments in community knowledge but occasionally major leaps to a new conception.

Every successful act of problem solving, no matter how trivial, creates knowledge of some sort, even if it is only knowledge that the answer to a particular algebra problem is $x = 12$. However, a problem solution that advances the state of community knowledge must meet higher-level criteria than just any run-of-the-mill problem solving. For example,

- It must have value to people other than the solver(s).
- It must have application beyond the situation that gave rise to it.
- Its value must endure beyond the moment.
- It must represent an improvement over solutions already available.

Problem solutions meeting these criteria usually also merit recognition as creative. These are minimal criteria for problem solving to be recognized as knowledge creation, yet they are sufficient to rule out most problem solving in everyday life and almost all problem solving as carried out in ordinary schoolwork. (With the problems normally assigned as schoolwork, the solution serves only as proof of competence; the value of work on such problems lies only in what individual students get out of the process.) The important point for the present discussion is that meeting criteria for knowledge creation is within the capabilities of even quite young students—provided the problems they work on are authentic ones and not merely exercises of academic skills.

Although some academic subject matter may have potential practical value or value in relation to public issues, the main utility of most academic knowledge is to enable the acquisition of more advanced knowledge. For most students, that is the only instrumental value in learning algebra and physics, for instance (allowing that it may also have personal value in terms of intellectual development). When a group of elementary school students produces what they perceive as an adequate explanatory account of rainbows, there may be immediate gratification in feelings of accomplishment, but the usefulness of their theory is in serving as a starting point for a better theory and for helping advance in broader efforts to understand light and vision. This is what advances in science and other basic knowledge-creating enterprises amount to and are generally something to be celebrated, not belittled. Furthermore, and advance that sets the stage for another tends toward more real-world issues of application when work proceeds in design mode. The examples of such knowledge creation by young students have never ceased to amaze us and to boost our faith in the future of civilization.

Educational Knowledge Building and Problems of Explanation

Knowledge creation in the world at large may be concerned with a wide range of practical, conceptual, moral, and other kinds of problems. As a general rule, however, all problems calling for knowledge creation have underlying problems of understanding which either must be solved or the solution of which will aid in solving the focal problem. One mark of novices in a domain is that they tend to plow ahead with seeking solutions to focal problems without attending to underlying problems of understanding. We have commonly seen this in classroom discussions. For example, in studying problems of endangered species, students are quick with proposed solutions: ban hunting, stop cutting down forests, and so forth. They may take sides and argue about solutions, perhaps seeking evidence to support their positions, but they neglect the question of why the species is in danger of extinction in the first place. That is a problem of explanation, often a complex one, but solving it will often reveal what is wrong with the simple solutions that arise immediately in discussion.

While understanding may be a personal, tacit matter, in the context of collaborative knowledge building understanding means explaining. "Explanation-driven" learning (Sandoval and Reiser 2004) recognizes this connection, as does Schank and Abelson's (1977) concept of "failure-driven" learning, according to which the failure of things to behave or turn out as expected drives a search for explanation. Failure-driven explanation has one serious limitation, however. We are inclined to pursue explanation only to the depth necessary to deal with the problem at hand and then stop; or, as E. O Wilson put it (1998, p. 61), our brains evolved "to survive in the world and only incidentally to understand it at a depth greater than is necessary to survive." But understanding at a level sufficient for dealing with the problem at hand is liable not to be sufficient for advancing the state of the art or knowledge in a community. Hence it is not sufficient for knowledge building.

It is quite understandable that in their daily lives people do not do the extra work needed to push explanation beyond the minimum necessary for dealing with problems at hand. But knowledge building/knowledge creation generally requires such extra work. Where are people going to acquire the necessary explanation-building practices and skills to become knowledge creators? For all its drawbacks, school is the ideal place for such learning, precisely because it is insulated from many of the external pressures that militate against reflection and pursuit of deeper explanation. Students considering whether to preserve the habitat of an endangered bird species or turn an area over to oil drilling do not have to come up with an immediate decision. They can have time (if the curriculum allows it) to pursue a thorough understanding of the problem situation, which includes problems of what constitutes an adequate habitat for the bird and what effect oil drilling has on the surrounding ecosystem. Focusing educational knowledge building on problems of understanding achieves two goals at once: It leads to deeper, more generalizable understanding of the "big ideas" that modern curricula endeavor to teach, and it cultivates the ability and disposition to push explanation seeking to the level necessary for innovative knowledge creation.

The Centrality of Knowledge Building Dialogue and the Need for Supportive Technology

The creative role of dialogue is widely recognized in the knowledge creation literature (e.g., von Krogh et al. 2000) and is the centerpiece of Tsoukas' (2009) theory of organizational knowledge creation. The importance of dialogue is no stranger to educational thought, either, dating as far back as Socrates and the type of understanding-seeking dialogue that still bears his name. The kind of dialogue of most interest in knowledge creation/knowledge building is dialogue that actually constitutes collaborative knowledge creation rather than only reflecting or contributing to it. Although it must be recognized that there is more to knowledge creation than discourse, it is also true that if knowledge-building dialogue fails, knowledge building fails, and conversely if a dialogue succeeds in advancing from one shared knowledge state to a more advanced knowledge state, knowledge has been created.

Sustained, goal-directed, knowledge-building dialogue is not something that comes naturally and easily to people, however (van Aalst 2009). There is a variety of software applications designed to support extended and deeper argumentation (Andriessen et al. 2003). However, this favors belief mode, as previously discussed. While it involves critical evaluation of ideas and the marshaling of evidence to support or disconfirm them, it is not a mode of discourse suited to producing and developing new knowledge. That calls for discourse conducted in design mode. Such discourse is the norm in research teams and calls for different kinds of support. For instance, Dunbar (1997) found collaborative research teams making extensive use of analogies, not for purposes of argument but for purposes of explaining and developing ideas. Knowledge Forum is a software environment, expressly designed to provide support for problem-oriented knowledge-building discourse, through scaffolds and mechanisms for building higher-level structures of ideas. It is evolving, with help from an international open-source team, to provide stronger supports for such knowledge-creating processes as problem analysis, analogy creation, strengthening of explanations, and meta-discourse (discourse about progress and difficulties in the main knowledge-creating effort). In more general terms, supportive knowledge building technology should help users students move up the rungs of the ladder leading from encyclopedic knowledge presentation to increasingly powerful knowledge creation.

Fun in Knowledge Building

We often hear phrases such as "knowledge is power," or "knowledge is wealth," but seldom "knowledge is fun." Many education students in our university courses have reacted with fear when given an assignment that calls for designing something new or tackling a novel problem. This may go some way toward explaining why they are reluctant to institute authentic knowledge building in their classrooms and prefer instead to stick with more routine project-based or inquiry methods. They see knowledge creation as risky, which of course it is. It can fail, as every inventor, theoretician, or design-based researcher knows. Failure is part of the process and is valued as such by knowledge creators of all kinds.

For people anxious about the possibility of failure, it is hard to believe that knowledge building can be much fun. But what we see in hundreds of classrooms is a rather peaceful sort of absorption enlivened by occasional flashes of excitement and joy—characteristic of the mental state that Csikszentmihalyi (1990) calls "flow." When we have asked students to compare knowledge building with other school experiences, they speak about the pleasure of working together, finding new information that helps advance an idea, seeing their theory taken up by someone else, discovering that the more you know the more you know what you don't know, understanding that learning is not so much a matter of the right answer as putting the pieces together in a way that makes sense, and viewing the knowledge advances that they have made as team successes. Students themselves have also been responsible for the spread of the pedagogy and technology to new classrooms, subjects, and schools. And when knowledge building is the norm, with students supporting each other, teachers report the class runs easily and enjoyably, for themselves as well as the students, with the students supporting one another and doing much of the correcting and reminding because they view the ideas that arise as community property.

"Play-based learning," which has been known by different names over the past century, seems to be making a comeback. As a reaction against excessive emphases on achievement standards and test preparation, its revival is quite understandable, but as so often happens in the pendulum swings of educational ideology, the reaction can go to excess as well. The excess we are hearing about from colleagues who encounter it is an insistence that play must exclude anything that might be called instruction or academic work. Of the almost two million web documents referencing "play-based learning" a mere 250 mention "play with ideas," and there is a great deal of duplicated text among the 250. And even in those documents there is hardly any mention of what play with ideas would mean or how it might occur. The most elaborated treatment we find is in a blog outlining 11 steps toward improving schooling, step 10 being "Build a Sandbox" (Duncan 2012):

> Every subject in school needs a "sandbox" – time set aside each week – to play with ideas and concepts learned in class. Let that sandbox be where students take apart and reassemble concepts, and find new and creative ways to anchor their learning.

The sandbox metaphor suggests students left alone to play however they wish, yet taking apart and reassembling concepts and finding creative ways to "anchor" their learning (possibly a reference to "anchored instruction"; Bransford et al. 1990) would seem to require substantial teacher or technological support and not to be things children would do spontaneously.

To naïve students numbers are real things, and play with numbers can be entertaining, quite apart from any concrete representations of the numbers. Play with numbers as such is play with ideas. Similarly, play with words is play with real things, and so is play with phonemes, which can have a vital role in learning to read an alphabetical language. Finally, children can treat ideas themselves as real things to play with. "Playing" with ideas means loosening the normal reality-based or task-based constraints and enjoying the freedom to make new combinations. For instance, a group of elementary school students, intrigued by the notion that people in Australia are upside-down, started playing with explanations of how this could be. So they came up with the idea that people in Australia are inside the globe rather than on the outside and, an even more fanciful theory that the earth is like a Ferris wheel, so that even though it turns, the passengers are always right side up. It cannot be supposed that the children took these ideas seriously. The students were carrying out abductive reasoning, inventing hypotheses which, if true, would explain the phenomenon in question. This is an essential kind of reasoning for knowledge creation (Pavola 2004), but the children were treating it as play. The students, we have suggested, were playing at it "in much the way that a kitten plays at catching mice" (Bereiter and Scardamalia 2013, p. 515).

Given enough freedom, young students will turn almost any academic activity into play. The challenge for pedagogy and technology designers is to provide supports and constraints that will shape the play along lines of useful knowledge creation without eliminating the spontaneity and fun. This is a challenge that the social and technological innovations alluded to earlier can help to meet. They need to provide an environment that is enjoyable to be in, while helping knowledge building to progress.

Conclusion: A Place for Everyone in a Knowledge-Creating Culture

We have said that knowledge creation as carried out in adult knowledge work and knowledge building as carried out in education are conceptually the same but with different hills to climb. The distinctive hill that education must climb has to do with the long-term future or the ones creating the knowledge. On one hand, knowledge building needs to make students more knowledgeable and competent (that is the learning effect) while on the other hand providing them with a knowledge base and conceptual tools for further knowledge building. This is a "knowledge age" way of saying something very similar to what John Dewey was saying throughout his long career. "Experience," as Dewey (1928) defined it, has a progressive, feed-forward character like knowledge building. It is growth that enables future growth. Dewey's concept of experience has been a hard idea to keep hold of and put into practice, however; Dewey himself grew discouraged with the extent to which the concept was misunderstood and misapplied (Seaman and Nelsen 2011). Knowledge building, once the concept is pried loose from learning, Gives Deweyan "experience" and objective embodiment. It is observable behavior and its products—ideas—though intangible, can nevertheless be specified and described. It is possible to visit a classroom and judge whether knowledge building is taking place; judging whether Deweyan "experience" is taking place is much harder.

Not every student will go on in life to be a knowledge worker. Knowledge building in schools must no be geared only to preparing students for such work. Education must take a larger view. The prospects are that in an innovation-driven knowledge society, it will become increasingly difficult for everyone to find valued and satisfying roles. This is really difficult hill education must climb; the problem cannot be wished away with homilies about everyone deserving a chance. That is true, but very far from being a solution. Knowledge building is not a solution either, but it can be a very positive step on the direction of enabling everyone to make a fulfilling place for themselves in whatever future unfolds. The positive step is helping every student to function in design mode and to bring a design thinking mindset to all kinds of situations, major or minor. Moreover, knowledge building in the classroom can help students learn to collaborate in design thinking, which is often necessary for it to succeed, and to hone communication and media skills that facilitate productive collaboration in design mode.

The answer to individual differences is not the kind of differentiation we once observed in a "model" classroom, where part of the class was engaged in preparing to perform a Shakespearean tragedy, while those with lower academic performance built a model of the Globe Theatre. Knowledge building is something for the whole class to engage in together, with everyone being a contributor. But ways of contributing can vary, depending on individual strengths and dispositions, and they can include not only contributions in the form of ideas but contributions to the community's morale, enthusiasm, and pleasure in accomplishment (Resendes 2013). These are all essential aspects of a successful knowledge-creating culture, whether in the classroom or in the workplace. Some student contributions can facilitate knowledge building without actually introducing substantive ideas: "I don't understand." "What does that mean?" "I found information we should consider." "How can you explain …?" "We need more information about…" " Let's do an experiment to ..." These are kinds of contribution that help sustain work with ideas and move knowledge-building discourse forward. Classroom knowledge building can on one hand give students experience in a wide variety of ways of contributing; on the other hand, it can help students develop their individual styles and skills of contributing so that each one has something distinctive to offer in any collaborative knowledge-building effort. That is perhaps the surest way of enabling everyone to find fulfilling roles themselves in a knowledge society and to feel part of the knowledge progress that is reshaping the world.

There are formidable barriers to instituting knowledge building in education. Some of these are the barriers any intellectually serious approach faces: excessive amounts of material to cover, excessive emphasis on test scores, and so on. But knowledge building also faces two barriers in the form of conventional beliefs: a belief that ordinary students lack the motivation and the ability to deal with ideas as such and a belief that basic academic skills and knowledge must be acquired before higher-level knowledge work can proceed. The weight of the evidence we and our collaborators have accumulated over past decades (summarized, for instance, in Scardamalia and Bereiter 2006, and Scardamalia and Egnatoff, 2010) contradicts these beliefs, but they are so firmly implanted in conventional educational wisdom that no amount of evidence is likely to dislodge them. Knowledge creation in businesses has also had to contend with conventional beliefs, but pressures to innovate have helped to overcome them.

Much of the business-oriented literature on knowledge creation and innovation consists of examples of how different corporations met this twin challenge. Educators also need examples, images of student groups successfully and happily developing such examples and explicating the principles behind them. There need to be examples from a great range of curriculum areas and student populations. "Building Cultural Capacity for Innovation" is a new international initiative that not only will develop the pedagogical and technological advances needed to make knowledge building work effectively in all areas but will provide images such that any teacher anywhere can look at them and say, "I could do that. With my help my students could do that."

References

Andriessen, J., Baker, M., & Suthers, D. (Eds.) (2003). *Arguing to learn: Confronting cognitions in computer-supported collaborative learning environments*. Dordrecht: Kluwer.

Bereiter, C., & Scardamalia, M. (1989). Intentional learning as a goal of instruction. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 361-392). Hillsdale, NJ: Lawrence Erlbaum Associates.

Bereiter, C., & Scardamalia, M. (2013). Self-organization in conceptual growth. Practical implications. In S. Vosniadou, (Ed.), *International handbook of research on conceptual change* (2nd ed.,) (pp. 504-519). New York: Routledge.

Bereiter, C., Scardamalia, M., & van Merriënboer, J. (2003). Learning to work creatively with knowledge. In E. De Corte, L. Verschaffel, & N. Entwistle (Eds.), *Powerful learning environments. Unraveling basic components and dimensions* (Advances in Learning and Instruction Series), pp. 55-68. Oxford: Elsevier Science.

Bransford, J. D., Sherwood, R. D., Hasselbring, T. S., Kinzer, C. K., & Williams, S. M. (1990). Anchored instruction: Why we need it and how technology can help. In D. Nix & R. J. Spiro (Eds.), *Cognition, education, and multimedia: Exploring ideas in high technology*. Hillsdale: Lawrence Erlbaum Associates.

Chan, C. K. K. (2013). Collaborative knowledge building: Towards a knowledge-creation perspective. In C. Hmelo-Silver, C. Chinn, C. K. K. Chan, & A. O'Donnell (Eds.), *The international handbook of collaborative learning* (pp. 437-461). New York: Routledge.

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. New York: Harper and Row.

Dewey, J. (1928). *Education as experience*. New York: Collier.

Dillenbourg, P. (2002). Over-scripting CSCL. In P. A. Kirschner (Ed.), *Three worlds of CSCL: Can we support CSCL* (pp. 61-91). Heerlen: Open University of the Netherlands.

Dunbar, K. (1997). How scientists think: Online creativity and conceptual change in science. In T. B. Ward, S. M. Smith, & S. Vaid (Eds.), *Conceptual structures and processes: Emergence, discovery and change* (pp. 461-493). Washington, DC: American Psychological Association.

Duncan, B. (2012, April 26). *Step 10: Build a sandbox* (web log comment). Retrived from http://foolscap.ca/?p=139

Fahrenheit 212. (2009). *White paper: Ideas are the easy part.* Web: http://www.fahrenheit-212.com/#/innovation/work/our-thinking/white-papers/ideas-are-the-easy-part/

Gersten, R., Carnine, D., & Woodward, J. (1987). Direct instruction research: The third decade. *Remedial & Special Education, 8*(6), 48-56.

Gourlay, S. (2006). Conceptualizing knowledge creation: A critique of Nonaka's theory. *Journal of Management Studies, 43*(7), 1415-1436.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimally guided instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75-86.

Levin, B. (2011). Mobilising research knowledge in education. *London Review of Education, 9*(1), 15-26.

Li, Y., & Kettinger, W. J. (2006). An evolutionary information-processing theory of knowledge creation. *Journal of the Association for Information Systems, 7*(9), 593-617.

Lindkvist L. (2005). Knowledge communities and knowledge collectivities. A typology of knowledge work in groups. *Journal of Management Studies*, 42(6), 1189-1210.

Lindkvist L., & Bengtsson, M. (2009). *Extending Nonaka's knowledge creation theory: How we know more than we can tell and tell more than we can know.* Paper presented at International Conference on Organizational Learning, Knowledge and Capabilities (OLKC), Amsterdam. Retrieved from www2.warwick.ac.uk/fac/soc/wbs/conf/olkc/archive/olkc4/papers/5blarslindkvist.pdf

Martin, R. L. (2009). *The design of business: Why design thinking is the next competitive advantage* (3rd ed.). Cambridge, MA: Harvard Business School Press.

Mayer, R. (2004). Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction. *American Pshychologist, 59,* 14-19.

Moen, A., Mørch, A. I., & Paavola, S. (Eds.). (2012). *Collaborative knowledge creation: Practices, tools, concepts*. Rotterdam: Sense Publishers.

Newell, A. (1980). Reasoning, problem solving and decision processes: The problem space as a fundamental category. In R. Nickerson (Ed.), *Attention and Performance VIII.* Hillsdale: Lawrence Erlbaum Associates.

Nickles, T. (Ed.). (1980). *Scientific discovery, logic and rationality*. Dordrecht: Reidel Publishing Company

Nonaka, I. (1991). The knowledge-creating company. *Harvard Business Review*, *69*(6), 96-104.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company*. New York: Oxford University Press.

Paavola, S. (2004). Abduction as a logic and methodology of discovery: The importance of strategies. *Foundations of Science, 9*(3), 267–283.

Paavola, S., & Hakkarainen, K. (2005). The knowledge creation metaphor – an emergent epistemological approach to learning. *Science & Education, 14*(6), 535-557.

Phillips, D. C. (1995). The good, the bad, the ugly: The many faces of constructivism. *Educational Researcher, 24*(7), 5-12.

Piaget, J. (1971). *Psychology and epistemology: Towards a theory of knowledge.* New York: Viking.

Polanyi, M. (1966). *The tacit dimension*. London: Routledge & Kegan Paul.

Popper, K. R. (1972). *Objective knowledge: An evolutionary approach*. Oxford: Clarendon.

Resendes, M. (2013, August). *Effect of formative feedback on enhancing ways of contributing to explanation-seeking dialogue in grade 2.* Paper presented at the Summer Institute on Knowledge Building, Puebla, Mexico. www. ikit.org/SI2013-Papers/4803-Resendes.pdf

Rosé, C. P., Wang, Y. C., Cui, Y., Arguello, J., Stegmann, K. Weinberger, A., & Fischer, F. (2008). Analyzing collaborative learning processes automatically: Exploiting the advances of computational linguistics in computer-supported collaborative learning. *International Journal of Computer Supported Collaborative Learning, 3*, 237-271.

Sandoval, W. A., & Reiser, B. J. (2004). Explanation-driven inquiry: Integrating conceptual and epistemic scaffolds for scientific inquiry. *Science Education, 8*, 345-373.

Scardamalia, M, & Bereiter, C. (1991). Higher levels of agency for children in knowledge building: A challenge for the design of new knowledge media. *The Journal of the Learning Sciences*, *1*(1), 37-68.

Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp. 97-118). New York: Cambridge University Press.

Scardamalia, M., & Bereiter, C. (in press). Knowledge building and knowledge creation: Theory, pedagogy, and technology. In K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (2nd ed.). New York: Cambridge University Press.

Scardamalia, M., & Egnatoff, W. (Eds.). (2010). *Canadian Journal of Learning and Technology, Special Issue on Knowledge Building, 36*(1). Retrieved from http://www.cjlt.ca/index.php/cjlt/issue/current

Scardamalia, M., Bereiter, C., & Lamon, M. (1994). The CSILE project: Trying to bring the classroom into World 3. In K. McGilley (Eds.), *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 201-228). Cambridge, MA: MIT Press.

Schank, R. C., & Abelson, R. P. (1977). *Scripts, plans, goals, and understanding*. Hillsdale: Lawrence Erlbaum Associates.

Seaman, J., & Nelsen, P.J. (2011). An overburdened term: Dewey's concept of "experience" as curriculum theory. *Education and Culture, 27*(1), 5-25.

Sinatra, G. M., & Pintrick, P. R. (Eds.). (2003). *Intentional conceptual change.* Mahwah: Lawrence Erlbaum Associates.

Stahl, G. (2006). *Group cognition*. Boston: MIT Press.

Tsoukas, H. (2009). A dialogical approach to the creation of new knowledge in organizations. *Organization Science, 20*, 941-957.

van Aalst, J. (2009). Distinguishing knowledge-sharing, knowledge-construction, and knowledge-creation discourses. *International Journal of Computer-Supported Collaborative Learning*, *4*(3), 259-287.

von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling knowledge creation*: *Unlocking the mystery of tacit knowledge.* New York: Oxford University Press.

Watson, P. (2005). *Ideas: A History from fire to Freud*. London: Weidenfeld & Nicolson.
Wilson, E. O. (1998). *Consilience: The unity of knowledge*. New York: Alfred E. Knopf.