4

Collective Cognitive Responsibility for the Advancement of Knowledge

Marlene Scardamalia

If there is any consensus about what education in a knowledge society should be like, it is to be found in a cluster of terms that pervade the oral and printed discourse on this issue—including especially the 'futuristic business literature' that Bereiter cites in his target article: *lifelong learning, flexibility, creativity, higher-order thinking skills, collaboration, distributed expertise, learning organizations, innovation, technological literacy.* At times these appear to be empty buzzwords, but they may also be thought of as attempts to give expression to a central intuition that has yet to be formulated in terms that are clear enough to be very useful in generating designs and policies. In this chapter I attempt to extract a main idea from these vague terms and show how it can be applied to generate a kind of education that really does address new challenges in a new way.

A central idea is *collective cognitive responsibility*. Although this concept does not capture everything suggested in the foregoing list of terms, it captures much that they have in common and something more. Let us first expand upon the idea in the context of adult work and then apply it in the context of education.

Collective Cognitive Responsibility in the Workplace

Expert medical teams, flight crews, and sports teams have begun to serve as models for the kinds of groups that are expected to carry on much of the higher-level work in knowledge-based enterprises. Expert teams exhibit continual learning, flexibility, good thinking, and collaboration; but they also exhibit other characteristics of a more distinctive nature. Although each member of the team may have particular expertise and particular duties, the team members are also able to take over for one another on a moment-to-moment basis. This provides a flexibility that enables the group effort to succeed despite unexpected complications. Along with the capability is a commitment on the part of each member to do whatever is necessary to make the team effort succeed. Expert teams have been around for a long time. The whaling crews that Melville described in *Moby Dick* exemplify what I have been describing. And, of course, expert sports teams exhibit just the combination of distinctive roles and skills on one hand and resourceful cooperation on the other that go to make up collective responsibility. What is new is that expert teams are becoming the paradigms for working groups of all kinds, replacing the bureaucratic and assembly line paradigms, in which roles are fixed and the way to handle the unexpected is to refer it to a higher level in the organization.

Collective responsibility, then, refers to the condition in which responsibility for the success of a group effort is distributed across all the members rather than being concentrated in the leader. Collective *cognitive* responsibility involves an added dimension. In modern enterprises there is usually a cognitive dimension in addition to the more tangible and practical aspects. This is obviously the case in research groups and other groups directly concerned with knowledge production, but it is also the case in enterprises where knowledge is subordinate to other goals. The members of an expert surgical team, for example, will ideally share responsibility not only for carrying out the surgical procedure; they also take collective responsibility for understanding what is happening, for staying cognitively on top of events as they unfold. In a well-functioning office, the staff will not only keep records and appointments in order and get required work out on time; they will also take responsibility for knowing what needs to be known and for insuring that others know what needs to be known. This is what is meant by collective cognitive responsibility.

In discussions with business people, I find that they instantly recognize cognitive responsibility as a problem, even though they have not previously thought of it in those terms. They recognize that their employees may be carrying out overt tasks with a high level of responsibility, but that things keep going wrong or projects deteriorate because problems are either not being recognized or are thought to be someone else's responsibility. The calendars, to-do lists, and project management software designed to keep people organized and on task provide little help in this regard. They may include cognitive items—"Decide...," "Look into...," "Plan..."—but these have the effect of limiting cognitive responsibility to particular people and of obscuring the continual living with problems and ideas that is part of the work life of an expert team. The irony is that in our so-called knowledge society, many people who are ostensibly doing knowledge work remain primarily engaged with material things, while the kind of knowledge processing that should be constantly going on in the background is slighted or left to management. Cognitive responsibility, it appears, is harder to maintain than responsibility for tangible outcomes.

The Withholding of Cognitive Responsibility in Schools

Schools present an especially interesting case with regard to cognitive responsibility. Cognitive objectives figure prominently in the reasons why schools exist. However it was the absence of collective cognitive responsibility as a goal for the teaching enterprise that led us to identify what we have elsewhere called the Teacher A model (Bereiter & Scardamalia, 1987).

In the Teacher A model, learning is a byproduct of doing schoolwork. The students' job is to do assigned work, in the case of a traditional classroom, or to carry out selfdirected projects and activities, in the case of the more modern classroom. The teachers' job is to plan and supervise the schoolwork, and they often do this well enough that the classroom presents a picture of happy, busy, hard-working students. Students are evaluated on the quality of their work and judged as working up to, below, or (among those labeled over-achievers) beyond their capacity. There may be evaluations of learning, often externally imposed. But for students falling short in such evaluations, the remedy is additional schoolwork. One diagnostic sign pointing to a Teacher A is an insatiable demand for exercise sheets. In the most extreme examples of Teacher A behavior, there is no such thing as *cognitive* responsibility, either on the part of the teacher or of the students. All the focus is on tasks and activities.

In the Teacher B model, the teacher assumes cognitive responsibility, but the students are not expected to do so. Most of instructional theory and design are aimed at some version of this model, and there are many variations, ranging from direct instruction to guided discovery. In a model B classroom, the teacher has cognitive objectives, both long-range and immediate, judges where the students are with respect to them, and gears actions to the attainment of those objectives. The students may be made aware of the objectives and encouraged to pursue them as well, but their actual *responsibility* is limited to overt tasks and activities, much like the students in a Teacher A classroom.

It should not be surprising, therefore, if the students themselves have a Teacher A, task-centered conception of learning, regardless of whether their teachers adhere to Model A or B. In studies of students' implicit theories of learning, this appears to be overwhelmingly the case, at least among elementary school students (Bereiter & Scardamalia, 1989). Participants were asked to suppose that they had an extra hour a week in which to learn anything they wished. The focus of the interview was on what they would do in order to learn, how long they thought it would take, how they would know if they had learned, what difficulties they anticipated, and how they would deal with them. Even young students indicated appropriate things they would do in order to learn—reading and asking questions if the purpose was to acquire factual knowledge, observing and practicing if the purpose was to acquire a skill. But with few exceptions they had no realistic idea of how long learning would take, and had no idea of how to cope with difficulties except by doing more of what they proposed to do. Their implicit theory, as we made it out, was that learning follows naturally from carrying out learning activities and completing tasks, one after another, and that is all there is to it—exactly the model we attribute to Teacher A. In only a few elementary school students did we see even a glimmer of what is common in the educated adults we interviewed, an awareness that learning can be problematic and may require strategic moves to bring it about.

Students have little idea of the strategic activity involved in learning if all such strategic activity has been carried out by their teachers and without their knowledge. There are indications that even among university students, many of them only have explicit strategies for memorization, lacking strategies for learning with understanding (Biggs, 1979). The Teacher C model, as we defined it, is distinguished by an effort to turn strategic cognitive activity over to the students. Many teachers would avow that this is what they are trying to do—to make students responsible for their own learning. However, in parallel interviews with teachers, we found that this often means performing tasks in a responsible manner—a Teacher A view of responsibility. For teachers to move from endorsing the Teacher C model to the point where they actually practice it is evidently a significant learning accomplishment in its own right, requiring a good deal of coaching, reflective practice, and mutual support (Anderson & Roit, 1993). It represents overcoming a career-long habituation to being the sole engineer of the learning process, however that is conceived.

I must emphasize that these remarks are not limited to teachers who pursue a didactic approach. The Teacher A and B models may be readily observed in classrooms conducted according to principles of informal, hands-on, child-centered, open education. The controls exercised by teachers in such classrooms may be less obvious, but they even more closely fit the term 'engineer.' Lillian Weber, in her influential book, *The English Infant School and Informal Education* (1971), quoted approvingly from a National Froebel Foundation handbook, which asserted that in an informal classroom

> the teacher actually has a more active directing part to play than on any planned instructional programme through which pupils are processed in an almost routine way. But the part to be played is of course a very different kind. It is based on not *imposing* anything on children, but on so closely co-operating with their native interests and drives that whatever they are led to do is felt as something that comes out of themselves. (quoted in Weber, 1971, p. 109)

Weber called this 'implementing' rather than 'directing'; but it is clearly not a matter of turning responsibility over to the children. If it is successful, the children are only aware of doing what they want, even though they have been subtly led to it by the teacher.

Collective Cognitive Responsibility in the Classroom

Why won't teachers turn higher levels of cognitive responsibility over to students? Answers may be sought in the need to maintain a position of authority and in disbelief in the capacity of students to shoulder such responsibility. But prior to these is a concrete fact of life: the ratio of one teacher to 30 or so students. This condition not only favors a centralized management structure; it also severely constrains the kind of discourse that can go on. As analysts of classroom discourse have observed, classroom exchanges are usually both initiated and terminated by the teacher (Sinclair & Coulthard, 1975). A typical exchange will start with the teacher asking a question, followed by a response from a student, and terminated by a remark by the teacher, often followed immediately by the initiation of a new exchange; e.g., 'Right. And what did the British do then?' With such a discourse structure, it should not be surprising that all the higher-level control of the discourse is exercised by the teacher. The students are cast into a perpetually reactive and receptive role.

Not much can be done to turn more responsibility over to the students unless the structure of classroom discourse is changed. Small group work has been the principal way of breaking the pattern in which all communication is mediated through the teacher. It can be quite productive (Barnes, 1977; Wells, Chang, & Maher, 1990), and it involves a substantial transfer of responsibility to the students. However, it also has its drawbacks. It may prove unmanageable unless the groups have definite and limited tasks, but this reduces the cognitive responsibility exercised by the students. Without the leavening influence of the teacher, there is a tendency for small group discussion to be dominated by the more outspoken students. Knowledge generated in small groups tends to be ephemeral, there being no recording of it and no teacher to serve as the corporate memory; and what is produced in one group is not readily available to others.

It was these seemingly intractable problems of discourse structure that first led me to investigate the possibilities of technology to change it. The first prototype of CSILE (Computer-Supported Intentional Learning Environments) was implemented in 1983 in an undergraduate Developmental Psychology course of over 300 students at York University. In years preceding the introduction of CSILE, I regularly asked students to write summaries of my lectures, as part of course requirements. These summaries provided a fascinating landscape of ideas that students brought to, and took from my lectures. Once I recovered from the shock of reading summaries that I thought could not possibly follow from my lecture, I began to see how these diverse interpretations provided a powerful teaching tool. However, reviewing and finding points of convergence and divergence in all of these summaries was a demanding and time-consuming activity for me. CSILE was first used to shift this responsibility to the students, by having them enter their ideas into a communal space where they could read each other's entries and engage in reflective activity. Prior to the introduction of the technology I could find no time-efficient means of turning this responsibility over to them. Experiments with CSILE led us to view cognitive responsibility as a social-cultural challenge, requiring a great deal more than individual intentional effort.

With the rapid growth of the Internet, many schools are moving to incorporate network communication into their educational activities. Most of these uses, however, make no fundamental change in the structure of classroom discourse or in the allocation of cognitive responsibility. In some cases the Internet merely provides a library of resources to be used in producing reports or other documents. In other cases joint research or design projects are organized among widely separated schools. Students may, for instance, contribute information on weather, plant life, or dialect in their respective localities, and then work to synthesize this information and draw generalizations from it. Such projects are rich in cognitive possibilities, but the higher-level cognitive work of goal-setting, planning, and monitoring will not be done by the students. Often it is not done by the teachers either, but by some central body that administers the project.[1] In model projects that we have seen, the students' activity is so highly structured for them in advance that it may amount to filling in cells in a spreadsheet, the rows and columns of which have been specified by the project organizers.

Schools also use e-mail, conferencing, or listserve applications that function as communication media, but generally not in ways that play a transformative role. Although communication with geographically distant classrooms has been enthusiastically endorsed by teachers, reports suggest that these play rather limited 'getting acquainted' roles. Discussions over the Internet show low levels of participation and a lack of continuity and moreover typically require a good deal of teacher direction (Guzdial, 1997; Hewitt & Scardamalia, 1998).

In the design of CSILE we were not directly concerned with these special-purpose applications of network technology. Instead, we aimed at altering the day-to-day discourse patterns, so that students would assume what we called in one article "higher levels of agency" (Scardamalia & Bereiter, 1991). We looked to networked computers as offering the possibility of a decentralized structure for the flow of information. CSILE linked students to a communal database created by the students themselves through the notes and comments that they contributed to it (Scardamalia et al. 1989).

Description of CSILE/Knowledge Forum

CSILE—the second-generation of which is called Knowledge Forum® (http://www.KnowledgeForum.com)—is an asynchronous discourse medium, which means that participants do not have to be engaged at the same time, as they do in an oral discussion or in a telephone conversation. In this way it is like e-mail. But, unlike e-mail, it does not consist of person-to-person messages. Instead, it consists of contributions to a community knowledge base, which resides on a server and is accessible to everyone in the network. Thus, the knowledge represented by notes in the database is preserved and continually available for search, retrieval, comment, reference, and revision. Various specific supports for knowledge building are provided, and keep being enhanced in successive versions of the software.

Knowledge Forum aims for fidelity to the ways work with ideas is carried out in the real world. Ideas are, of course, central to high-level knowledge work of all kinds. Research, scholarship, and invention indeed lose their character unless everything that is done directly or indirectly derives from and feeds into the further development of ideas. Ideas are seldom treated in isolation. They are systemically interconnected—one idea subsumes, contradicts, constrains, or otherwise relates to a number of others. To gain understanding is to explore these interconnections, and to drill deeper while *rising-above*, to gain broader perspective. Successful knowledge building, we may say, exhibits *deep*

---

[1] The Ministry of Education in British Columbia maintains a Web page devoted to cross-school projects, some of which are evidently administered by a branch of the Ministry. See http://www.etc.bc.ca/tdebhome/projects.html.

embedding, both as regards the embedding of ideas in larger conceptual structures and the embedding of ideas in the practices of the knowledge building community. Participants share responsibility for community knowledge, in addition to individual achievement.

Knowledge Forum in its current stage of development permits a depth of embedding that goes well beyond what is possible with other forms of so-called knowledgeware, such as the threaded discourse systems common on the Web. A simple Knowledge Forum note may be thought of as the embodiment of a single idea; but the note is identified with a problem and with "scaffolds," which give the note a role in more extended work with ideas such as theory-refinement, evidence gathering, argumentation, literary interpretation, and so forth. Furthermore, every note has a place in one or more views. The views themselves are graphical representations of higher-level conceptual structures and are constructed by participants to give greater meaning to the notes they contain. Students, teachers, and telementors or tele-experts (experts invited to join the online discourse) share responsibility for ensuring that these views do justice to the notes and at the same time represent their best collective understanding. Views help to establish a high standard for knowledge work. Participants know that what is represented in these view reflects the collective best of the community. Views may also be use to enter official curriculum frameworks. Students then link their notes to goal statements, to determine the extent to which their efforts meet or supersede the goals that ministries and departments of education have for them. Notes can live in multiple views (e.g., a curriculum-standards view, a previously constructed student-generated view, a view created by a tele-expert, and so forth). Participants are encouraged to create increasingly high-level 'rise-above' views that point to other views, or 'rise-above' notes, which subsume other notes. They can annotate or 'build on' or quote someone else's note. Quotes result in automatic links being established between the notes, along with bibliographic cross-references. In short, Knowledge Forum supports deep embeddedness: with notes and views serving to embed ideas in increasingly demanding contexts, going deeper into the content while at the same time situating these ideas in views that provide an integrative context for them. This deep embeddedness is what brings ideas to the center of their work, and in turn enables collective cognitive responsibility.

These capabilities only become effective, of course, if the social practices of the classroom make use of them. Thus there has developed along with the technology a knowledge building pedagogy, where the embeddedness idea comes to pervade the very culture of the classroom. I will later characterize this pedagogy by a set of distinctive attributes and illustrate these with examples. The overarching principle, however, is to foster collective cognitive responsibility. The first challenge is to progressively turn over to students the responsibility of using notes and views to create a valuable shared knowledge resource for their community.

The second challenge is insuring that ideas always remain the focus of this responsibility, that the activities and the mechanics never obscure the goals that give meaning and purpose to their tasks. This represents the largest single challenge to efforts to make knowledge building a reality in schools. All the traditions of schooling—both the traditions of teacher-directed instruction and the traditions of child-centered activity methods—are arraigned against it. These traditions, in turn, are grounded in the social reality of one teacher having to manage 20 to 40 children. These combine to make activities, not ideas, the center of classroom life. Changing this, so that ideas move to the center and activities become subordinate, represents a dramatic shift (Scardamalia, 1997). The classroom may still look much the same, just as the heavens still look the same to one who has undergone the Copernican switch, but everything is understood differently and it becomes possible to move into new levels of work with ideas that could not even have been imagined before.

In summary, the challenge addressed by Knowledge Forum and knowledge building pedagogy is *to engage students in the collaborative solution of knowledge problems, in such a way that responsibility for the success of the effort is shared by the students and teacher instead of being borne by the teacher alone.*

Grasping the Idea of Idea-Centered Education

Like the Copernican Revolution, the change from an activity-centered to an idea-centered view of education has an all-or-none character (Scardamalia 1999). There is a real sense in which you either get it or you don't. However, there is this added difficulty with the educational change: Most modern teachers believe they already put ideas at the center. Teaching for understanding and 'constructivism'—the idea that learners construct their own knowledge—are widely proclaimed and they seem to be saying what I have been saying only in different words. They are, of course, related to knowledge building. Knowledge building is a way of teaching for understanding and, as Bereiter (2002) makes clear, it is constructivist. But it is also radically different from most of what goes on in the name of teaching for understanding and constructivism. Because of the slipperiness of words, the difference is difficult to convey, although teachers are very much aware of the difference once they have made the transition.

To clarify what is distinctive about knowledge building and the technology that supports it, I have listed in Table 4.1 twelve ideas that in combination set a knowledge building classroom off as profoundly different from even the best of traditional and modern classrooms. Table 4.1 also suggests the close links between knowledge building practices and technology, which in combination help to produce these shifts. Fortunately, the interconnectedness of these ideas means that implementing one tends to unlock the others. Although in principle you could have the practices without the technology, we have found the technology to be important not only for practical reasons—to overcome the objective obstacles created by classroom conditions—but also for conceptual reasons. The core ideas of knowledge building often come across as abstract and fanciful until people see them embodied in the technology. The combined practices and technology also help align participants and their environment so that knowledge advancement: 1. is in the social fabric of the organization; 2. is enhanced through primacy given to creative work with ideas; and 3. represents sustained work at the frontiers of understanding (Scardamalia 2000; 2001). This culture captures the natural human tendency to play creatively with ideas, and expands it to the unnatural human capacity to exceed the boundaries of what is known and knowable--to exceed expectations rather than settle into routines. Creating a shared intellectual resource and a rallying point for community work helps to provide an alternative to tasks, lessons, projects and other expert-designed motivators of work, replacing them with a system of interactions around ideas that leads to the continual improvement of these ideas. Tasks and projects are completed, but they are not reduced to routine or sufficing strategies that obscure the broader goals that gave meaning to them in the first place.

Table 4.1
Socio-Cognitive and Technological Determinants of Knowledge Building

REAL IDEAS, AUTHENTIC PROBLEMS

Socio-cognitive dynamics: Knowledge problems arise from efforts to understand the world. Ideas produced or appropriated are as real as things touched and felt. Problems are ones that learners really care about—usually very different from textbook problems and puzzles.

Technological dynamics: *Knowledge Forum* creates a culture for creative work with ideas. Notes and views serve as direct reflections of the core work of the organization and of the ideas of its creators.

IMPROVABLE IDEAS

Socio-cognitive dynamics: All ideas are treated as improvable. Participants work continuously to improve the quality, coherence, and utility of ideas. For such work to prosper, the culture must be one of psychological safety, so that people feel safe in taking risks—revealing ignorance, voicing half-baked notions, giving and receiving criticism.

Technological dynamics: *Knowledge Forum* supports recursion in all aspects of its design—there is always a higher level, there is always opportunity to revise. Background operations reflect change: continual improvement, revision, theory refinement.

IDEA DIVERSITY

Socio-cognitive dynamics: Idea diversity is essential to the development of knowledge advancement, just as biodiversity is essential to the success of an ecosystem. To understand an idea is to understand the ideas that surround it, including those that stand in contrast to it. Idea diversity creates a rich environment for ideas to evolve into new and more refined forms.

Technological dynamics: Bulletin boards, discussion forums, and so forth, provide opportunities for diversity of ideas but they only weakly support interaction of ideas. In *Knowledge Forum*, facilities for linking ideas and for bringing different combinations of ideas together in different notes and views promote the interaction that makes productive use of diversity.

RISE ABOVE

Socio-cognitive dynamics: Creative knowledge building entails working toward more inclusive principles and higher-level formulations of problems. It means learning to work with diversity, complexity and messiness, and out of that achieve new syntheses. By moving to higher planes of understanding knowledge builders transcend trivialities and oversimplifications and move beyond current best practices.

Technological dynamics: In expert knowledge building teams, as in *Knowledge Forum,* conditions to which people adapt change as a result of the successes of other people in the environment. Adapting means adapting to a progressive set of conditions that keep raising the bar. Rise-above notes and views support unlimited embedding of ideas in increasingly advanced structures, and support emergent rather than fixed goals.

EPISTEMIC AGENCY

Socio-cognitive dynamics: Participants set forth their ideas and negotiate a fit between personal ideas and ideas of others, using contrasts to spark and sustain knowledge advancement rather than depending on others to chart that course for them. They deal with problems of goals, motivation, evaluation, and long-range planning that are normally left to teachers or managers.

Technological dynamics: *Knowledge Forum* provides support for theory construction and refinement and for viewing ideas in the context of related but different ideas. Scaffolds for high level knowledge processes are reflected in the use and variety of epistemological terms (such as conjecture, wonder, hypothesize, and so forth), and in the corresponding growth in conceptual content.

COMMUNITY KNOWLEDGE, COLLECTIVE RESPONSIBILITY

Socio-cognitive dynamics: Contributions to shared, top-level goals of the organization are prized and rewarded as much as individual achievements. Team members produce ideas of value to others and share responsibility for the overall advancement of knowledge in the community.

Technological dynamics: *Knowledge Forum's* open, collaborative workspace holds conceptual artifacts that are contributed by community members. Community membership is defined in terms of reading and building-on the notes of others, ensuring that views are informative and helpful for the community, linking views in ways that demonstrate view interrelationships. More generally, effectiveness of the community is gauged by the extent to which all participants share responsibility for the highest levels of the organization's knowledge work.

DEMOCRATIZING KNOWLEDGE

Socio-cognitive dynamics: All participants are legitimate contributors to the shared goals of the community; all take pride in knowledge advances achieved by the group. The diversity and divisional differences represented in any organization do not lead to separations along knowledge have/have-not or innovator/non-innovator lines. All are empowered to engage in knowledge innovation.

Technological dynamics: There is a way into the central knowledge space for all participants; analytic tools allow participants to assess evenness of contributions and other indicators of the extent to which all members do their part in a joint enterprise.

SYMMETRIC KNOWLEDGE ADVANCEMENT

Socio-cognitive dynamics: Expertise is distributed within and between communities. Symmetry in knowledge advancement results from knowledge exchange and from the fact that to give knowledge is to get knowledge.

Technological dynamics: *Knowledge Forum* supports virtual visits and the co-construction of views across teams, both within and between communities. Extended communities serve to embed ideas in increasingly broad social contexts. Symmetry in knowledge work is directly reflected in the flow and reworking of information across views and databases of different teams and communities.

PERVASIVE KNOWLEDGE BUILDING

Socio-cognitive dynamics: Knowledge building is not confined to particular occasions or subjects but pervades mental life—in and out of school.

Technological dynamics: *Knowledge Forum* encourages knowledge building as the central and guiding force of the community's mission, not as an add-on. Contributions to collective resources reflect all aspects of knowledge work

CONSTRUCTIVE USES OF AUTHORITATIVE SOURCES

Socio-cognitive dynamics: To know a discipline is to be in touch with the present state and growing edge of knowledge in the field. This requires respect and understanding of authoritative sources, combined with a critical stance toward them.

Technological dynamics: *Knowledge Forum* encourages participants to use authoritative sources, along with other information sources, as data for their own knowledge building and idea-improving processes. Participants are encouraged to contribute new information to central resources, to reference and build-on authoritative sources; bibliographies are generated automatically from referenced resources.

KNOWLEDGE BUILDING DISCOURSE

Socio-cognitive dynamics: The discourse of knowledge building communities results in more than the sharing of knowledge; the knowledge itself is refined and transformed through the discursive practices of the community—practices that have the advancement of knowledge as their explicit goal.

Technological dynamics: *Knowledge Forum* supports rich intertextual and inter-team notes and views and emergent rather than predetermined goals and workspaces. Revision, reference, and annotation further encourage participants to identify shared problems and gaps in understanding and to advance understanding beyond the level of the most knowledgeable individual.

EMBEDDED AND TRANSFORMATIVE ASSESSMENT

Socio-cognitive dynamics: Assessment is part of the effort to advance knowledge—it is used to identify problems as the work proceeds and is embedded in the day-to-day workings of the organization. The community engages in its own internal assessment, which is both more fine-tuned and rigorous than external assessment, and serves to ensure that the community's work will exceed the expectations of external assessors

Technological dynamics: Standards and benchmarks are objects of discourse in *Knowledge Forum*, to be annotated, built on, and risen above. Increases in literacy, twenty-first-century skills, and productivity are by-products of mainline knowledge work, and advance in parallel.

To illustrate the ideas summarized in Table 4.1, I narrate four examples from actual classrooms. They illustrate both knowledge building pedagogy and the role that *Knowledge Forum* plays in it. I hope they will also convey a sense of the whole that Table 4.1 cannot convey—a sense of the spirit of classroom communities in which ideas are at the center, knowledge building is the job, and collective cognitive responsibility is nurtured over the course of the elementary school years. For ease of reference, I use italics to refer to the specific ideas elaborated in Table 4.1.

1. GRADE 1 SCIENCE: ADAPTATION, CYCLES, AND ENERGY

The starting point for knowledge-building in *Knowledge Forum* is a *view.* Figure 4.1 shows a view co-constructed by a Grade 1 teacher, her students, and a teacher-researcher to launch a year-long study of the topics that provincial guidelines specified for Grade 1 science. A view may contain *notes* or pointers to other views.

In this case, as a top-level organizer, the view contains only pointers to other views. In Figure 4.2, we follow one of these pointers, the one in the Fall view that points to work on leaves. Here there are a number of notes authored by the children. As the note titles indicate, they do not contain miscellaneous information about leaves but instead focus on a problem that the students themselves had come up with (*real ideas, authentic problems*): What causes leaves to change color in the fall?

Figure 4.3 shows one of the notes, which hypothesizes that plugs develop that prevent sap from getting to the leaves, causing the chlorophyll to die. Some other theories, illustrating the principle of *idea diversity*, are

"Fall – I think the chlorophyll goes into the tree to keep warm for the winter."

"I think leaves change color because when the leaf falls down I think that the chlorophyll goes to the outside of the leaf so it leaks off the leaf."

"Because it's too cold for the chlorophyll to make food for the tree."

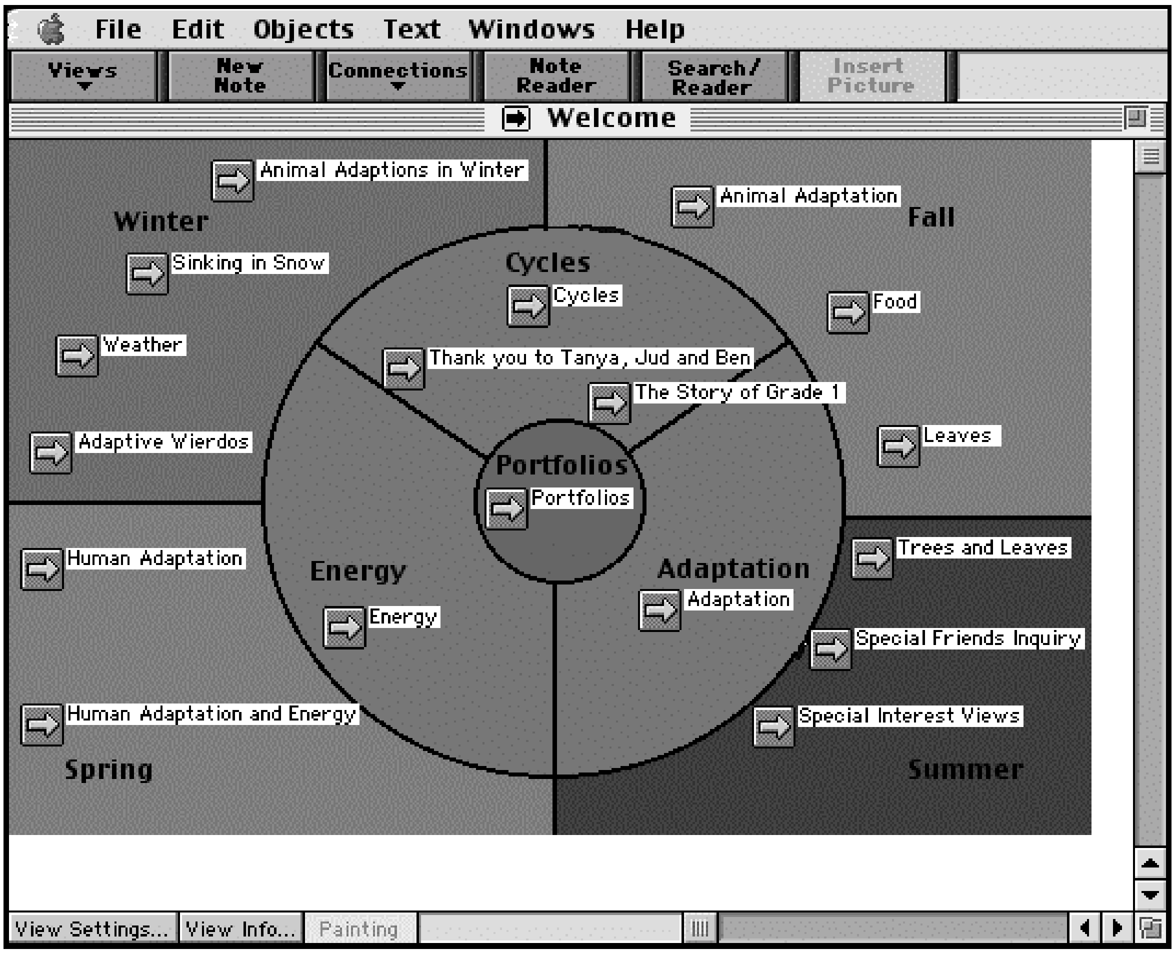

Figure 4.1
Top-level 'Welcome' view titled Adaptation, Cycles, and Energy, with pointers to related views.

What we cannot see here, but what the teacher reports in the virtual tour of her knowledge base,[2] is an account of a field trip the students took to a maple-tree farm to see how maple syrup is made. One child, watching the sap flow from the tree, noted that

[2] The virtual tour, which describes these events in the teacher's own words and voice is available at (http://ikit.org/virtualsuite/visits)

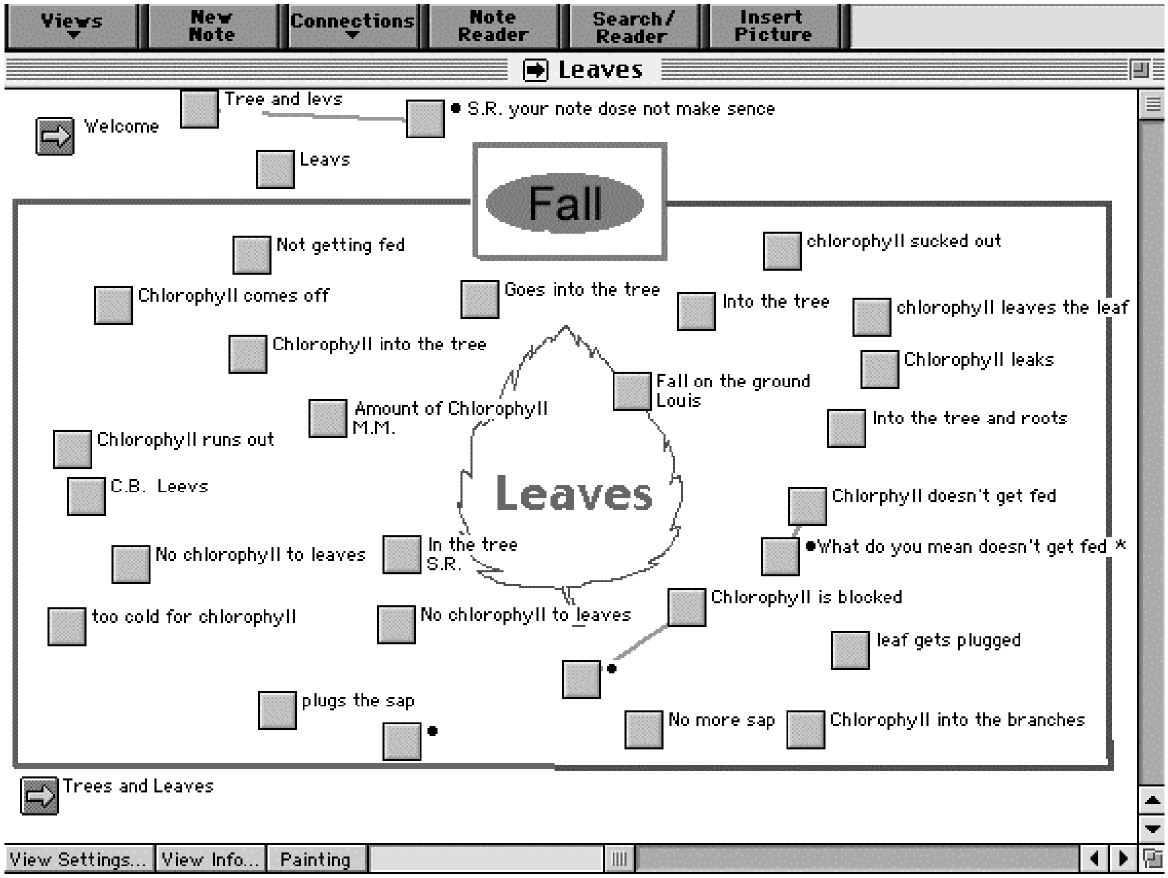

Figure 4.2
The 'Leaves' sub-view follows a pointer from the 'Welcome' View (Figure 4.1). Children's notes focus on the problem: What causes leaves to change color in the fall?

her theory regarding chlorophyll must be wrong, because the sap that she saw was not green. Others raised many other issues about what they saw, and how the flow of sap gave them new ideas about the internal structure of a tree, and the relation of its internal structure to their theories. What was impressive, as the teacher reports, is that the work in Knowledge Forum and the visit to the maple-syrup farm were not closely related in time. She was surprised and delighted that a relationship was discovered, as she had not anticipated it herself. This juxtaposition of theory and relevant evidence suggests *epistemic agency*: Personally held beliefs are viewed in relation to ideas suggested by others and by everyday phenomena. We also know, from the teacher's account, that the students became actively engaged in other efforts to test their theories, through self-invented experiments. For instance, they collected leaves and placed them in the freezer in the basement of the school. This was their way of testing the time and degree of color change they might see with the leaves. As the above accounts suggest, their theories seemed real enough to them that they carried them to the playground, took them along with them to the field trip, and reportedly to the dinner table. The transportability of these ideas, I propose, follows from their articulation and availability in a communal space where they became an object for inquiry by everyone.

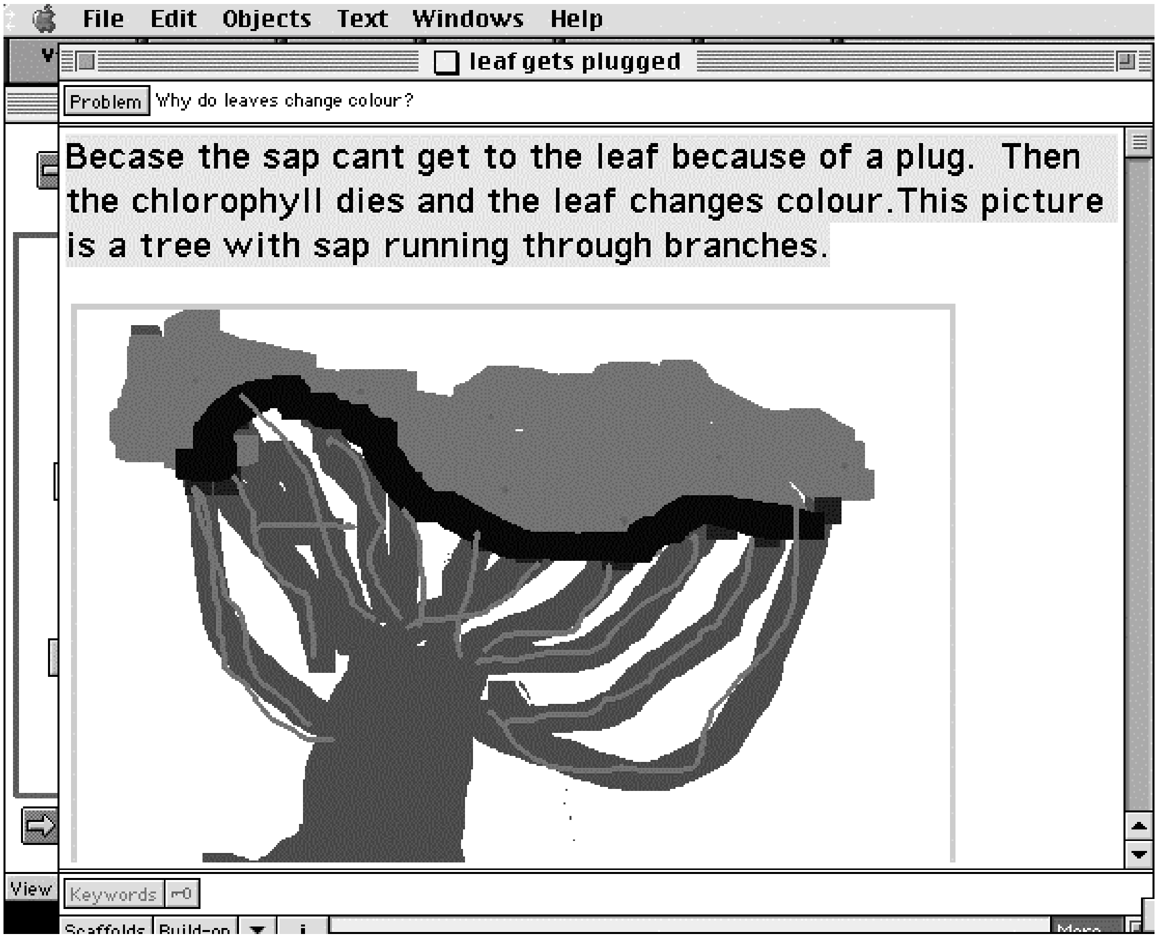

Figure 4.3
'Leaf gets plugged' theory note from the 'Leaves' view (Figure 4.2). Shows student's hypothesis explaining why leaves change color.

We see evidence of the extended life of these ideas in a subsequent view (Figure 4.4). This view contains several notes of a special kind called '*rise-above*' notes. These notes are the result of the students and teacher working together to collect into one common note similar theoretical accounts. One rise-above note reads, "These notes share the idea that the sap gets plugged and that is why the leaves change color." Students who felt that accurately characterized their theory then dragged and dropped their notes into the rise-above note, removing them from the screen but making them still available through the rise-above. Thus we see the *rise-above* principle in action. As suggested by the various text and graphics notes that the students wrote, there was a way in for everyone—a common discourse space to aid the *democratization of knowledge*.

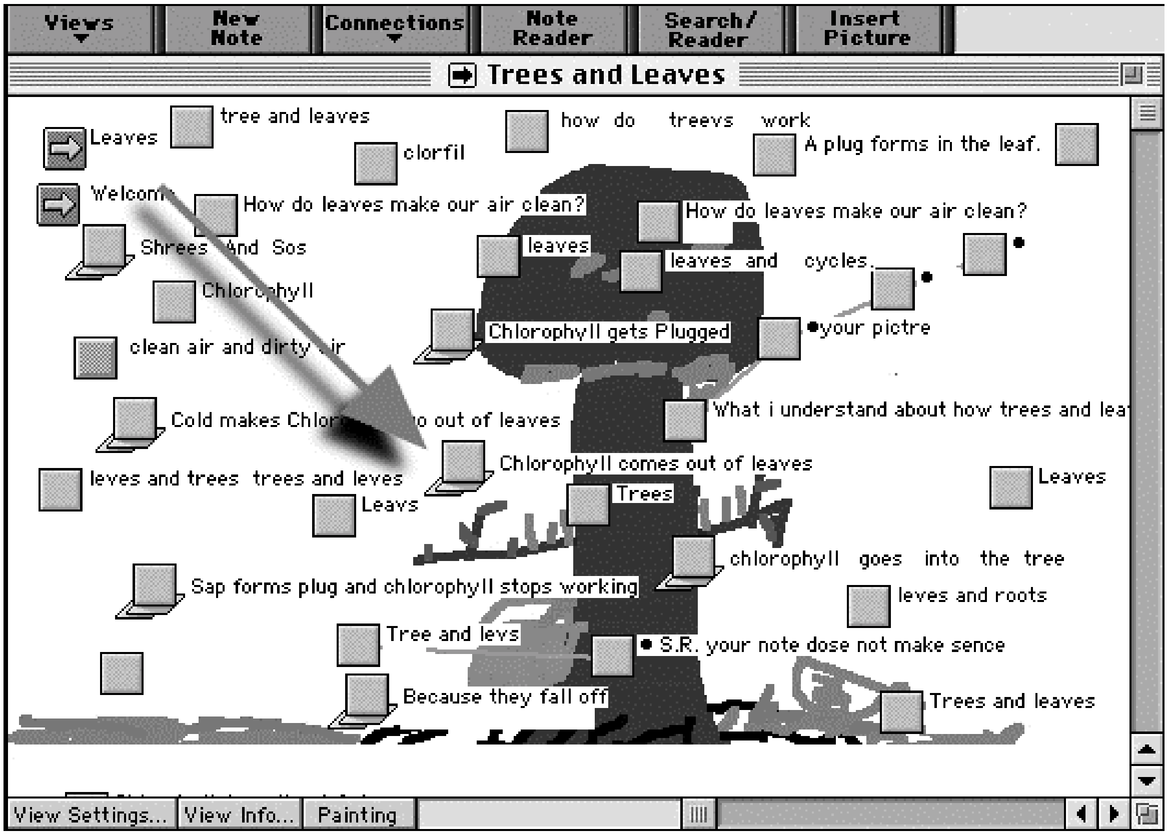

Figure 4.4
'Trees and Leaves' view contains rise-above notes.

Pervasive knowledge building is reflected in the extensibility of their work with ideas in many contexts, both in school and out, and across diverse knowledge media. *Community knowledge, collective responsibility* is evident in their work with one another. *Symmetric knowledge advancement* is suggested by the teacher's report that she gained a deeper understanding of photosynthesis and of why plants turn different colors in the fall through her involvement in the students' inquiries.

GRADE 3. LITERATURE STUDIES

Notes in Knowledge Forum have customizable scaffolds to support high level knowledge processes. Figure 4.5 illustrates a 'theory building' scaffold that we have used to encourage young students to engage in Theory Building while they write their notes.

The Grade 3 students edited this scaffold, saving the first 'My theory' support, adding a new support titled 'Did you know?' and deleting the rest. 'Did you know?' was their favorite scaffold support, and could be found in almost all of their writings on the Harry Potter novel they were reading. "*Did you know* Quidditch is a game that you play on broomsticks?" "*Did you know* if you catch the Snitch your team gets 150 points and the game is over?" "*Did you know* J.K. moved twice from her home. In her school on the first day they had a test!" After the students produced this first round of notes the teacher introduced them to the contrast between 'knowledge telling' and 'knowledge transforming' discourse, as set out in educational literature (Bereiter and Scardamalia 1993). One child had an insight: perhaps '*Did you know?*' was their favorite scaffold

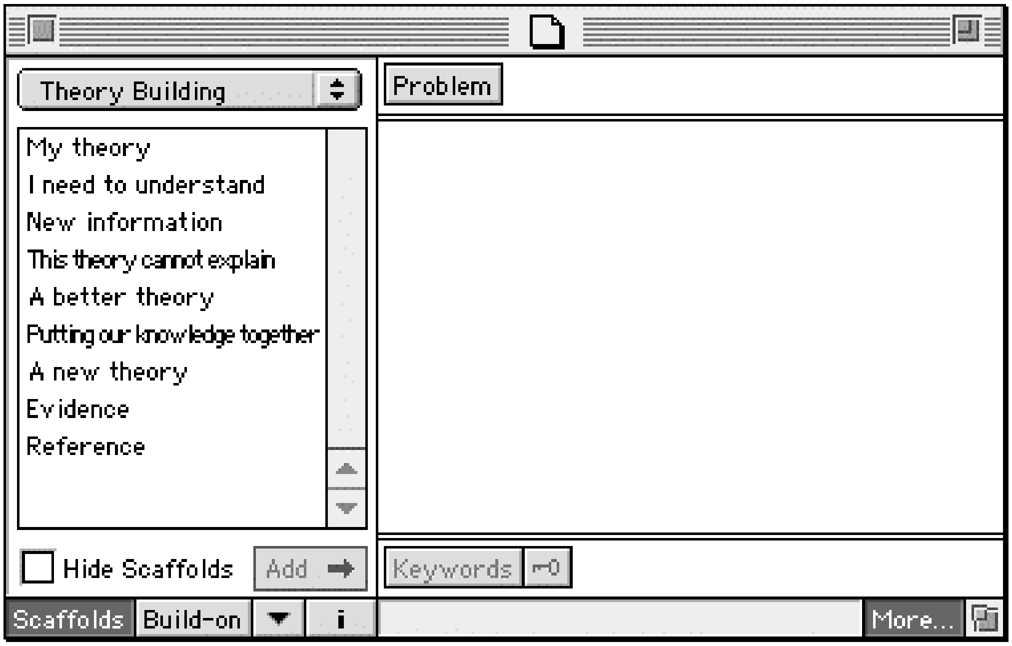

Figure 4.5
Note with the 'Theory Building' scaffold.

support because it was easy to use. This child suggested that '*Did you know?*' supported knowledge telling, and that their notes were just repeating information from the text. Others argued that they were doing more than knowledge telling—that they were learning to find key information in texts. Regardless of their different interpretations, they collectively decided to revise the scaffold, to bring back more of the original items, and to add some new supports. There was a corresponding shift in their Knowledge Forum notes, from recording information taken from the text to interpretive accounts, frequently scaffolded through the *evidence* support. This brief episode demonstrates their ability to distinguish knowledge telling from *knowledge building discourse*, and to purposefully shift to the latter. It also demonstrates their ability to exert *epistemic agency* in the design of their environment, to *democratize knowledge* through provision of supports designed to encourage all participants to engage in increasingly demanding knowledge work, and to make *constructive use of authoritative sources* regarding the distinction between knowledge telling and knowledge transforming discourse.

GRADE 4: 'OUR LIGHT LEARNINGS'

We now move ahead to a Grade 4 classroom and to the final stages of an extended inquiry into problems having to do with light. Although the inquiry dealt with issues that commonly figure in the study of light in elementary science classes, it is worth noting that, in keeping with *real ideas, authentic problems*, the study was launched in this case by questions about lighting that arose from the class's attending a performance of a Shakespeare play.

Figure 4.6, like Figure 4.1, represents a view-of-views. In this case, however, the views are actually depicted, in the form of miniatures of views actually constructed by the students in each of six areas of inquiry—angles and reflections, sources of light, and so on. Following the pointer to any of those views would take you to a view that contains the actual notes produced by students in their work in that problem area. Students helped maintain each view, determining what was and was not appropriate to appear on it, looking to the arrangement of notes on the view, and so on. Thus they took collective cognitive responsibility for view construction.

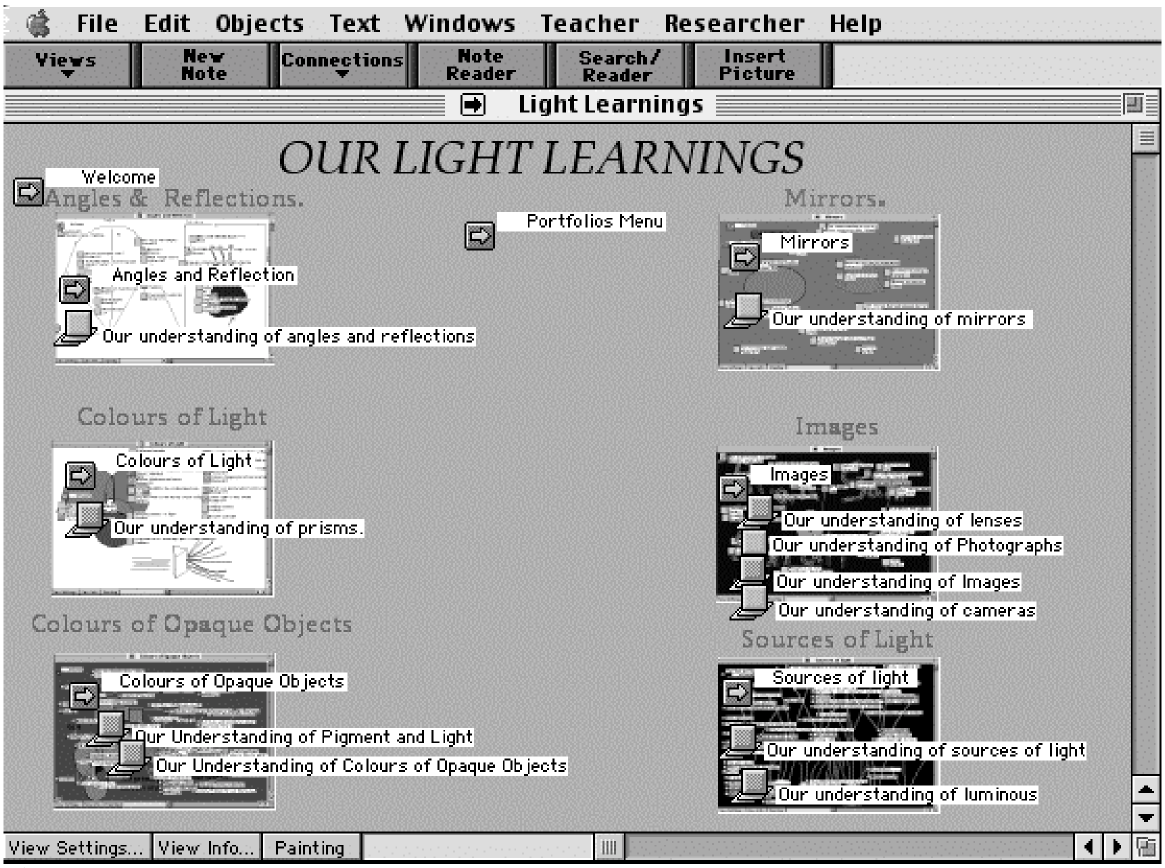

Figure 4.6
'Light Learnings' 'view-of'views', Grade 4 classroom.

The notes attached to the 'Our Light Learnings' view are all *rise-above* notes. Whereas in Grade 1 such notes were produced by the teacher and the students were responsible only for deciding whether their own notes belonged in a particular rise-above, in Grade 4 'rising above' became a major responsibility of the students. Figure 4.7 shows one of the resulting notes and Figure 4.8 shows the first part of another, longer rise-above note. The similar structure of the two notes is due to Knowledge Forum's customizable scaffolds that were in this case designed to fit this particular task of producing a note that integrates 'Our theory,' 'Our evidence,' 'Putting our knowledge together,' and 'What we still need to understand.' The numbers in small boxes are links to supportive notes in other views, which are also referenced at the bottom of the rise-above note. (Referencing occurs automatically whenever one note or a portion of a note is copied into another

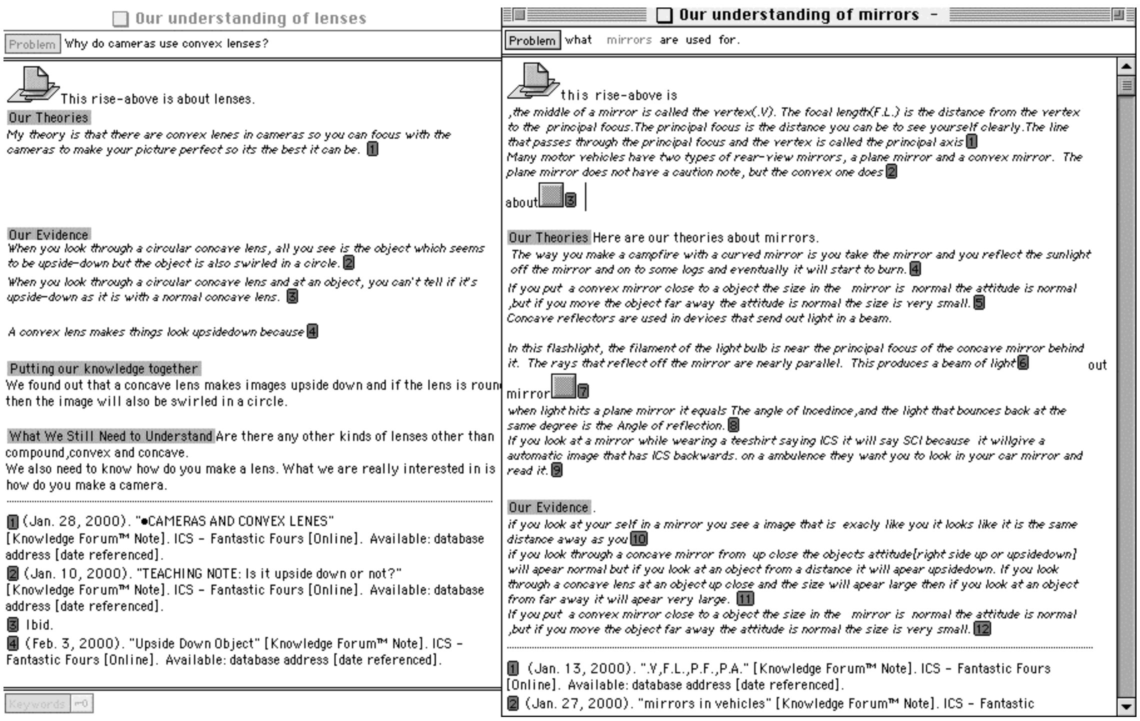

Figure 4.7
Two rise-above notes from the 'Our Light Learning' view.

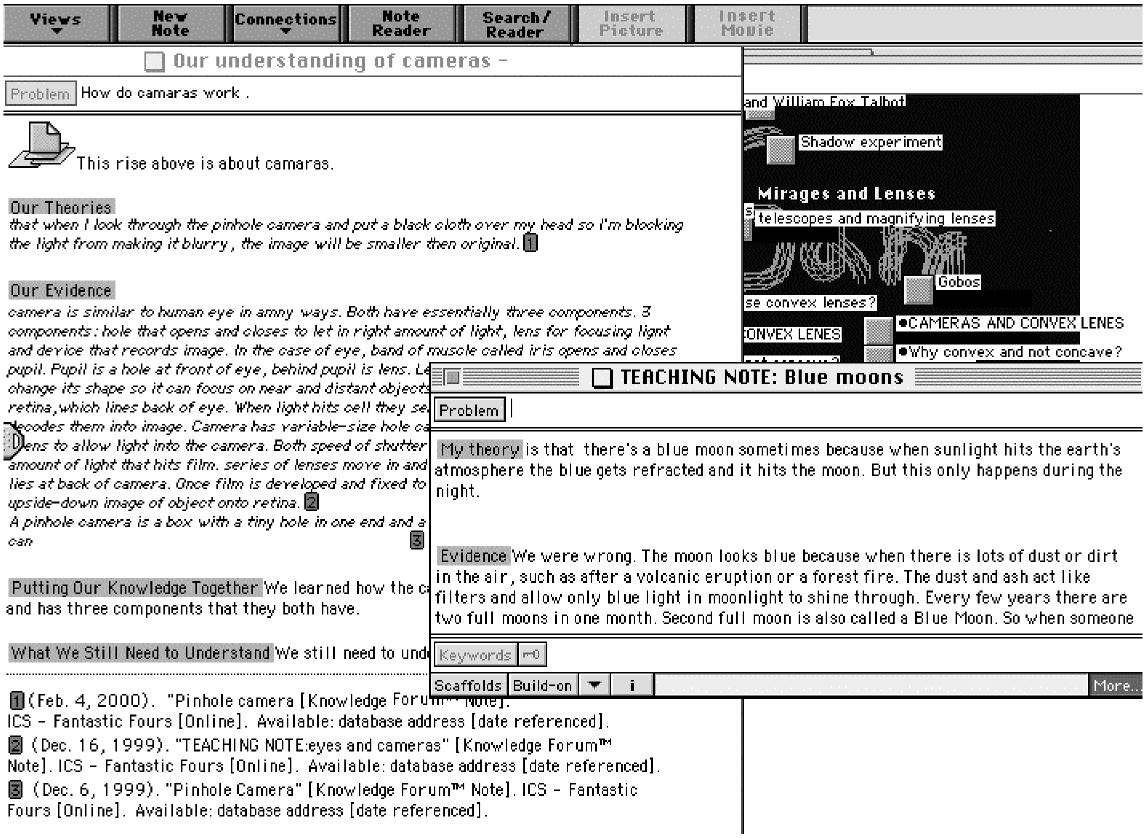

Figure 4.8
Two different rise-above notes from the 'Images' view.

and the copied material appears as a quote. Thus students cite each other, they do not copy ideas and claim them as their own.) The result is, depending on how you look at it, a richly interconnected hypertext document or a review article with ample references. In any case, it graphically represents *community knowledge, collective responsibility* brought about through *knowledge building discourse*, and *idea diversity.*

GRADE 5/6. ISLANDS, EVOLUTION, AND BIODIVERSITY

A number of advances in collective cognitive responsibility are evident in the grade 5/6 class. These students explored problems related to islands, evolution, and biodiversity. While the Grade 1 teacher was the primary designer of the top-level curriculum view, the Grade 6 students took greater responsibility for the top-level as well as local views. They organized their work around curriculum objectives, and divided up responsibilities, as reflected in a set of linked views that coordinated their work. For example, they divided up the island problem space so that some students conducted research on different island types (Coral Atoll, Volcanic, Sedimentary, Continental); others on locations (Hawaii, Galapagos, Java, Madagascar, Iceland); and others on issues regarding the formation and inhabitants of islands (species, how to create an island, the earth's layers). The depth of their inquiry was reflected in their efforts to learn from each other and in their portfolios (personal views with select contributions from the database, annotated to provide a reflective overview). For example, here is one student's portfolio summary note: "*This (*referring to a note selected for the portfolio) *is my theory of evolution. This* (another selected note) *is Jason's note that sparked a huge debate. The debate was at first about whether my theory or Alexa's theory of evolution was right, but eventually it became about whether science is always right, and the validity of resources (*three portfolio notes were selected that focus on the validity of resources). *These notes are about whether science is always right, and whether how old it is affects how correct it is.*" There is clear demonstration of *constructive use of authoritative sources*. Additionally, committees of students were responsible for maintaining views, and videotapes of discussions among view managers indicate that *collective cognitive responsibility* and *embedded and transformative assessment* were taken very seriously by students, as they dealt with the tension between ensuring that their view contained contributions to knowledge and being fair to their classmates. An analysis of the work in this classroom demonstrates important shifts from learning to knowledge building, along all of the dimensions indicated in Table 4.1.

The teacher's role in all four of these examples is largely that of helping students shoulder their responsibilities and advancing knowledge along with them. It is noteworthy that three of the four examples are from teachers' first-year efforts with knowledge building and Knowledge Forum. I attribute the quick uptake to various factors: 1. the school philosophy is in keeping with this work, and the principal fosters community engagement and stewardship; 2. two other teachers in the school had been engaged in the two preceding years, with impressive results and models to offer to new teachers; 3. research grants allowed us to hire one of the two experienced teachers, to work directly with the three new teachers in a teacher-researcher capacity. All of these teachers and the principal are exciting colleagues, working within a laboratory school setting that prizes teacher-research arrangements.[3] Thus this faster-than-usual (Blumenfeld et al. 2000) uptake of new ideas and school-based innovation is attributable to multiple factors, which surely extend beyond those I have listed.

One of the enabling factors, as the examples suggest, is the technology itself. It is what enables cognitive responsibility to be distributed. Hewitt (1996) has traced the changes that took place in one classroom over three years as the focus was shifted from personal knowledge accumulation to the collaborative solution of knowledge problems. One of the interesting markers of this shift was an increase in the number of epistemological terms occurring in students' notes. Hakkarainen (1995) studied a number of CSILE discussions on science topics to ascertain the extent to which they conform to canons of scientific inquiry. His conclusion, buttressed by independent

---

[3]The school is the Institute for Child Study of the University of Toronto (ICS). ICS participants are Patti MacDonald (Grade 1), Mary Jane Moreau, (Grade 3), Richard Messina (Grade 4), Bev Caswell (Grades 5-6), Richard Reeve (teacher-researcher), and Elizabeth Morley (Principal). The project researcher is Mary Lamon.

judgments from two philosophers of science, is that the students collectively exhibit a high level of what may properly be called scientific thinking. Other in-progress research indicates that reading other students' notes is predictive of later achievement on advanced placement tests (Power 2000). If that is correct, it suggests that awareness of diverse ideas helps one clarify and think through scientific ideas. Other research indicates that students who explicate their naive conceptions are more likely to make contributions to knowledge advancement—and these advances are more related to articulating their ideas than to their scholastic achievement test scores (Van Aalst 1999). These findings suggest that articulating ideas and bringing misconceptions out in the open—generally, dealing with *idea diversity*—provides an effective context for knowledge advancement.

Expanding Possibilities

Although the laboratory school from which the preceding examples were taken plays a key role in advancing the pedagogical and technological frontier, other important innovative work is going on in at least 12 countries, in grades 1 to university, including inner-city schools, and in health care settings, public-service organizations, small businesses, and other settings. We have now begun to create virtual visits (http://ikit.org/virtualsuite/visits) that allow members of this worldwide community to visit each other electronically. Could such efforts eventually provide a reasonable substitute for live visits to knowledge building classrooms? Will they foster knowledge building practices for newcomers? It is impossible to know at this early stage. There is another development that suggests exciting new possibilities. Underlying these environments are analytic tools that allow us to examine students' individual and collective contributions (text and graphic notes and views in Knowledge Forum). These analytic tools provide detailed accounts of development that can be made available to teachers (and potentially to students) immediately, and these results can also be fed directly back into the process of continual improvement. Thus the goal of *embedded, and transformative assessment* is becoming increasingly possible and exciting.

If we distinguish knowledge building from learning, then a legitimate concern is with what individual children learn from taking part in knowledge building activities. Assessments are reassuring about general levels of academic achievement (Scardamalia et al. 1992; Scardamalia, Bereiter, and Lamon 1994): Compared to non-CSILE controls, CSILE students did significantly better in language and reading and show no deficit in other areas. Their literacy advantage grows with additional years using CSILE/Knowledge Forum, and they show advantages in graphical literacy (Scardamalia et al. 1994). The students also show more sophisticated understandings about knowledge and learning (Scardamalia et al. 1994). That is as close as we can currently come to documenting what I am here suggesting is the major advantage students in a knowledge-building classroom carry with them into a knowledge society: ability and willingness to take on responsibility for the collective solution of knowledge problems.

Barriers to Adoption

Although most educators who visit a knowledge-building classroom are impressed, many of them to a high degree, there are a number of concerns that stand in the way of wholehearted commitment to the idea of knowledge building. The first, and most insidious—because it seldom comes out in the open—is the disbelief that most children have the motivation and ability to do the things the educator has just witnessed. This shows up first as a suggestion that the children and the teacher, or both, are exceptional. In practice it shows up as a tendency to overstructure and overmanage activity, with the result that some of the essential characteristics of knowledge building are sacrificed—particularly, authentic problems, epistemic agency, and cognitive responsibility.

A second, and surprisingly widespread, concern is that students will learn something wrong. This concern crops up even among educators who are well aware of the extensive research indicating how profound is the mislearning that normally occurs in schooling. Research carried out in CSILE classrooms indicates that the spread of misconceptions and false information is minimal, and is easily exceeded by the amount of correction of misinformation and misunderstanding that go on. This is not to claim that the students are immune to the misconceptions that pervade society. But knowledge building work in a medium like Knowledge Forum brings them out in the open, whereas they usually remain hidden in conventional school work, and the process of idea improvement, if sustained, can be relied on to overcome many of them.

A third concern arises from a belief that can be summarized as 'Learn first, produce later.' This belief is common throughout the education world and underlies much educational practice, especially in liberal education. It is devastating to the approach I have been describing, because it implies that creative work with ideas can come only after a long period of absorbing knowledge that has already become established. This belief is implicit in such terms as 'basic education' and 'foundations.' And, of course, the belief has considerable substance. Many kinds of human performance presuppose prior learning; we would not want to entrust airline piloting or thoracic surgery to on-the-job learning, even though we recognize that such skills reach a high level only through practice.

Picasso is often held up as an exemplar of the 'learn first' approach. Although he was an extraordinary innovator, he devoted his early years to assiduously mastering classical styles and techniques. But it is important to note that he learned by producing art works—derivative ones, to be sure, but we may presume that like most art students he was simultaneously striving to produce works of artistic merit and to learn. According to self-reports, students in the knowledge-building classes we work with also have this dual motivation. They are consciously trying to learn but at the same time they are trying to produce theories, ideas, and other objects of scientific or scholarly merit. In this chapter I have emphasized producing ideas—knowledge building; in another paper, included as an appendix to this book, Bereiter and I deal with intentional learning.

Although we have never witnessed knowledge building unaccompanied by learning, we have witnessed a great deal of learning that was never converted to knowledge building. We continually advise teachers against assigning a portion of the day to 'learning' and a different portion to 'knowledge building.' Such a division weakens both, whereas they ought naturally to reinforce and boost each other. Even on into their late careers, knowledge builders ought to be simultaneously engaged in advancing the frontiers of knowledge and in personal learning. That is what a non-trivial conception of 'lifelong learning' ought to comprise. I have been arguing that this combination of knowledge building and learning can start in early childhood.

Even after conceptual barriers have been removed, and even with the strongest technological supports, instituting a knowledge building classroom remains a challenge. It entails creating a culture in the classroom that is not a miniature of the surrounding culture but rather is a model of what that surrounding culture might become—a culture in which the creation and improvement of ideas pervades social life. One of the most successful teachers reported that it usually took him from September to January or February each year, to get his grade 5-6 class functioning well as a knowledge building community. This was true even though, because of the split-grade structure, a number of the students each year were carry-overs from the year before. Once the community was functioning, however, new students entering the class could join it with relative ease. That was because the other students could help with the enculturation. We have seen some evidence that when a school-wide culture of knowledge building is established, the year-to-year problems of culture-building diminish and instead there is an upward progression where each year the culture advances beyond where it was before. Then you have a genuine knowledge building culture, with its own dynamic of continual advancement. That, I maintain, is what schools must become if they are to play their part in the Knowledge Age.[4]

References

Anderson, V. and M. Roit. 1993. Planning and Implementing Collaborative Strategy Instruction for Delayed Readers in Grades 6-10. *Elementary School Journal* 94 (2), 121-137.

Barnes, D. 1977. *Communication and Learning in Small Groups.* London: Penguin.

Bereiter, C. 2002. Liberal Education in a Knowledge Society. Chapter 2 in this volume.

Bereiter, C. and M. Scardamalia. 1987. An Attainable Version of High Literacy: Approaches to Teaching Higher-Order Skills in Reading and Writing. *Curriculum Inquiry* 17 (1), 19-30.

[4] The author wishes to acknowledge the generous support of Bell Canada, the Ontario Ministry of Education, the Social Sciences and Humanities Research Council of Canada, and the TeleLearning Network of Centres of Excellence. I am indebted to the students and teachers who contributed their time and talents to this project, and to the entire CSILE/Knowledge Forum team, without whose contributions the work reported here would not have been possible. I am also grateful to Carl Bereiter and André Carus for their thoughtful input to this manuscript.

———. 1989. Intentional Learning As A Goal of Instruction. In Lauren B. Resnick, ed., *Knowing, Learning, and Instruction: Essays in Honor of Robert Glaser* (Hillsdale, NJ:,Erlbaum), pp. 361-392.

———. 1993. *Surpassing Ourselves: An inquiry into the Nature and Implications of Expertise.* Chicago: Open Court.

Biggs, J. B. 1979. Individual Differences in Study Processes and the Quality of Learning Outcomes. *Higher Education* 8, 381-394.

Blumenfeld, P., B.J. Fishman, J. Krajcik, R.W. Marx, and E. Soloway. 2000. Creating Usable Innovations in Systemic Reform: Scaling Up Technology-Embedded Project-Based Science in Urban Schools. *Educational Psychologist* 35(3), 149-164.

Guzdial, M. 1997. Information Ecology of Collaborations in Educational Settings: Influence of Tool. In R. Hall, N. Miyake, and N. Enyedy, eds., *CSCL '97* (Toronto: CSCL), pp. 83-90.

Hakkarainen, K. 1995. *Collaborative Inquiry in the Computer-Supported Intentional Learning Environments.* Paper presented at the European Association for Research on Learning and Instruction, Nijmegen, Netherlands.

Hewitt, J. 1996. Progress toward a Knowledge-Building Community. Unpublished doctoral dissertation, University of Toronto.

Hewitt, J. and M. Scardamalia. 1998. Design Principles for the Support of Distributed Processes. *Educational Psychology Review* 10 (1), 75-96. http://csile.oise.utoronto.ca/abstracts/distributed/

Power, D. November 2000. Global Partnerships-Telelearning for Sustaining rural Communities: The Changing Role of Small Schools in Knowledge Societies? K. Stevens (Chair). Symposium conducted at the Telelearning 2000 5th Annual Conference, Toronto.

Scardamalia, M. April 1997. The Knowledge Society Challenge. Presentation conducted at the Colloquium Series, Harvard University. Retrieved 23rd January 2002 from http://kf.oise.utoronto.ca/ms/ideas.html

———. 1999. Moving Ideas to the Center. In L. Harasim, ed., *Wisdom and Wizardry: Celebrating the Pioneers of Online Education* (Vancouver: Telelearning), pp. 14-15.

———. 2000. Can Schools Enter a Knowledge Society? In M. Selinger and J. Wynn, eds., *Educational Technology and the Impact on Teaching and Learning* (Abingdon, RM), pp. 5-10.

———. 2001. Getting Real about 21st-century Education. *Journal of Educational Change* 2, 171-76.

Scardamalia, M., and C. Bereiter. 1991. Higher Levels of Agency for Children in Knowledge-Building: A Challenge for the Design of New Knowledge Media. *Journal of the Learning Sciences* 1(1), 37-68.

Scardamalia, M., C. Bereiter, C. Brett, P.J. Burtis, C. Calhoun, N. Smith Lea. 1992. Educational Applications of a Networked Communal Database. *Interactive Learning Environments* 2(1), 45-71.

Scardamalia, M., C. Bereiter, and M. Lamon. 1994. The CSILE Project: Trying to Bring the Classroom into World 3. In K. McGilley, ed., *Classroom Lessons: Integrating Cognitive Theory and Classroom Practice* (Cambridge, MA: MIT Press), pp. 201-228.

Scardamalia, M., C. Bereiter, R.S. McLean, J. Swallow, and E. Woodruff. 1989. Computer-Supported Intentional Learning Environments. *Journal of Educational Computing Research* 5(1), 51-68.

Sinclair, J. McH. And J.M. Coulthard. 1975. *Towards an Analysis of Discourse: The English Used by Teachers and Pupils.* London: Oxford University Press.

van Aalst, J.C.W. 1999. Learning, Knowledge Building, and Subject Matter Knowledge in School Science. Unpublished doctoral dissertation, University of Toronto.

Weber, L. 1971. *The English Infant School and Informal Education.* Englewood Cliffs, NJ: Prentice-Hall.

Wells, G., G.L. Chang, and A. Maher. 1990. Creating Classroom Communities of Literate Thinkers. In S. Sharan, ed., *Co-operative Learning: Theory and Research* (New York: Praeger), pp. 95-121.