CHAPTER

1

From a Focus on Tasks to a Focus on Understanding: The Cultural Transformation of a Toronto Classroom

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INTRODUCTION

For the past ten years, a grade six teacher at Huron Public School in Toronto, Canada has been working with researchers on the Computer-Supported Intentional Learning Environments (CSILE) project to transform the way that students work and learn in his classroom. Over that period, he has gradually abandoned many of the task-centered practices common to Canadian schooling (e.g., project-based work, class assignments) in favor of new practices that focus on understanding. Large portions of each school day are now dedicated to the kind of progressive problem solving that one usually associates with scientific research teams. With minimal teacher guidance, students collaboratively pose problems of understanding, invent and debate theories, engage in research, and generally strive to make intellectual progress in key curricular areas. In short, the teacher has fashioned a culture of classroom practice that is grounded in intentional learning and collaborative inquiry. Scardamalia and Bereiter (1994) refer to this educational model as a *Knowledge Building Community*.

This chapter begins with an examination of the rationale for employing a knowledge-centered pedagogy in place of traditional task-based instruction and continues with an exploration of how the Huron School teacher transformed his classroom over a crucial three-year period. Particular attention is paid to the teacher's early difficulties, the strategies he subsequently devised, and the way in which a technology called CSILE supported the teacher's efforts to foster a Knowledge Building Community.

CONCERNS ABOUT CONTEMPORARY EDUCATIONAL PRACTICES

Proponents of constructivism often criticize contemporary educational practices as being grounded in the "transmission model" (e.g., Pea & Gomez, 1992) of learning. The transmission model suggests that learning is a process of knowledge transfer (Fig. 1.1) in which knowledge originates with the teacher (or some other source of domain expertise) and is then transmitted through the instructor's words and actions to the learner (Reddy, 1979). Given this model, the quality of the teacher's presentation becomes the key determinant of the student's understanding. If ideas are presented clearly then learning is likely to occur. However, if students have difficulty understanding a particular concept, the lesson needs to be improved. Thus, pedagogical success is tightly tied to the teacher's ability to deliver content, while the students' role is to receive the knowledge passed on to them.

Critics of the transmission model suggest that its portrayal of the learning process is overly simplistic and neglects recent findings about the nature of knowledge and the role of the learner. In particular, it fails to acknowledge that understanding develops through an active, constructive process. Therefore, real educational gains may be made if schools abandon their transmission model methods and work to help students become active knowledge creators instead of passive knowledge recipients. However, this argument for instructional reform must be tempered with the recognition that modern day teachers are not unsympathetic or unknowledgeable with regard to constructivist theory. Most educators encourage active learning, problem solving, and peer collaboration. The transmission model should not be viewed as a reflection of contemporary teaching philosophy, but as a collection of historic and cultural beliefs that persist in the form of traditional

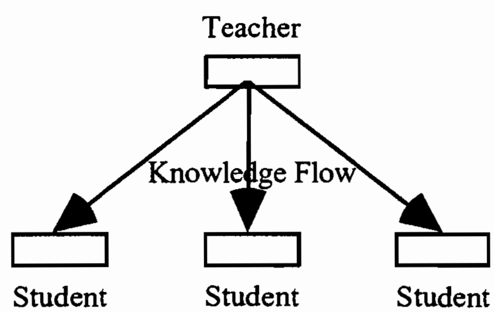

FIG. 1.1. The transmission model of learning.

classroom practices. Unfortunately, these practices are so deeply entrenched in the day-to-day activities of the classroom that they are rarely recognized or questioned, even though they may have adverse effects on learning. Four examples are presented below:

1. Teacher Domination of the Educational Agenda

Generally, it is the teacher, not the student, who organizes the lessons, who asks the questions, and who synthesizes and summarizes. By taking charge of these operations, the teacher preempts the possibility of students planning their own research, developing their own explanations, and identifying their own problems of understanding (Scardamalia & Bereiter, 1991). Instead of actively pursuing personal knowledge advancement, as autonomous learners do, students are, instead, placed in the more passive position of responding to the teacher's directions. This is not to suggest that immature and inexperienced students can immediately take charge of their own learning. However, as Scardamalia and Bereiter (1991a) point out, it may be feasible to develop a curriculum in which students *gradually* take responsibility for high-level operations. Traditional notions that the teacher must control all aspects of the instructional agenda persist to the end of high school, resulting in an unhealthy dependence on instructor guidance and direction. This problem becomes most evident when high school students enter college and find many of these supports missing.

2. Artificial Discourse

One common type of classroom discourse is the three-step IRF sequence. The IRF is a two-person dialogue in which the teacher *initiates* with a question, the student *responds*, and the teacher provides *feedback* (Sinclair & Coulthard, 1975; Mehan, 1979). This three-step procedure is used to focus learners on particular aspects of the curriculum materials, to elicit information as a demonstration of understanding, and to provide immediate feedback. Thus, the IRF engages students, while simultaneously informing the teacher about learner comprehension (Mercer, 1992; Newman, Griffin, & Cole, 1989). The dominant role that the IRF plays in contemporary classrooms demonstrates its ongoing importance as an instructional tool.

Critics of the IRF do not dispute its use as an instrument for engaging students or for uncovering misconceptions, but they question its long-term effect when used as a dominant form of classroom dialogue. One problem with the IRF is that it provides no impetus for students to assess their own comprehension level or to pose questions that will advance their own understanding, because these are the teacher's responsibilities. In this fashion, it reinforces the teacher's control of high-level processes (see #1 above). A second problem is that the IRF misrepresents learning as a simplistic process of producing answers to questions. It fails to convey the progressive, iterative nature of learning and the importance of making connections between ideas.

3. An Orientation Toward Classroom Products

A third line of criticism concerns an excessive orientation toward educational products (Scardamalia & Bereiter, 1997; Brown & Day, 1983). A large part of what students do in school is concerned with completing workbook exercises, writing essays, preparing projects, and so forth. For some learners, task-based learning can be educationally worthwhile. However, researchers have found that some students are remarkably adept at completing classroom assignments while doing a minimal amount of actual learning (Scardamalia & Bereiter, 1997). Studies of student behavior have identified several strategies that are inefficient from an educational standpoint but are effective techniques for rapid task-completion. Two of these strategies are called *Knowledge-Telling and Copy-Delete*:

1. Knowledge-telling is the practice of reiterating what one already knows about a particular topic. It is a convenient strategy to use with project-based work because it does not require planning, organization, or the analysis of new information (Scardamalia & Bereiter, 1991b, 1993).
2. Copy-delete is a pseudo-summarization strategy in which students copy much of the source material, occasionally deleting phrases or rewording them slightly. This gives the appearance of understanding without the accompanying cognitive effort (Brown & Day, 1983).

Strategies such as knowledge-telling and copy-delete emerge because the student's goal (e.g., to hand in a project by a certain date) is different from the teacher's goal (e.g., to encourage learning) (Scardamalia & Bereiter, 1997). Even students who recognize and appreciate the underlying learning objectives are often placed in a situation in which deadlines and other time pressures encourage practices that are educationally suboptimal.

4. An Emphasis on Memorization

A fourth criticism of standard classroom practice is that it inadvertently encourages memorization as a learning strategy. The IRF sequence can have this effect. Studies have shown that the average time taken between the teacher's initiation and the student's response can be as little as one second

(Rowe, 1974). This favors students who have answers already prepared over those who take the time to formulate a solution. Test-taking is another classroom practice that can promote memorization. As Scardamalia and Bereiter (1997) point out, test questions that require the recall of a list of items (e.g., "Name the four steps of the water cycle") promote rote learning over understanding. The importance of rapid recall during oral questioning (e.g., IRF) and examination may lead many students to mistakenly believe that learning and memorization are the same thing.

Perceiving learning as a process of memorization may result in what Whitehead (1929) calls *inert knowledge*. To extend understanding, the learner must establish connections between new information and their own existing understanding of the world (Wittrock, 1974). King (1994) points out that this is consistent with the distinction that Kintsch (1986) makes between *learning about text* and *learning from text*. Associations developed within the context of the new material are less effective for long-term recall than those developed between the new material and one's prior understanding. Students who use memorization as a learning strategy are less likely to make these ties.

Students' tendencies to answer questions without understanding, to use memorization inappropriately, and to engage in knowledge-telling and copy-delete strategies are probably familiar behaviors to most teachers. Experienced instructors may call attention to some of these practices and attempt to deal with them directly. However, some researchers are now suggesting that simply changing student behavior is not enough; what is required is a transformation of the classroom conditions that make inefficient strategies feasible and practical (Scardamalia & Bereiter, 1997). That is, there is a need to move away from artificial discourse, teacher monopolization of high-level operations, and product-orientation. In short, there is a call for new cultures of learning that overcome the deep-rooted and persistent problems in our current school system.

THE KNOWLEDGE BUILDING COMMUNITY MODEL

One alternative to conventional task-based instruction is Scardamalia and Bereiter's (1994) Knowledge Building Community model. A Knowledge Building Community is a group of individuals dedicated to sharing and advancing the knowledge of the collective. Research teams in the scientific disciplines provide a prototypical example, although Knowledge Building Communities can also exist in the form of film societies, literary cliques, industrial firms, and even some families (Scardamalia & Bereiter, 1993). What is unique about a Knowledge Building Community is not formal association (e.g., department, club, company) or physical proximity (although that is

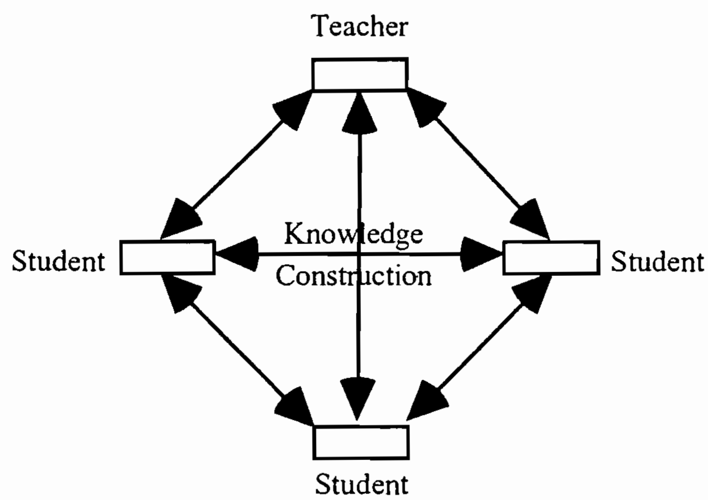

FIG. 1.2. The Knowledge Building Community model.

often important) but, rather, a commitment among its members to invest their resources in the collective construction of knowledge.

Applied to schools, the Knowledge Building Community model is distinctly different from contemporary in-class practices, which appear to oscillate between didactic and child-centered instruction. First, rather than knowledge being viewed as flowing from the teacher (Fig. 1.1), it instead becomes a collaborative construct of many participants (Fig. 1.2). Second, not all students deal with the same subject matter. Instead, different people develop expertise in different areas. This is a significant departure from standard school practice in which everyone in the class learns essentially the same thing. In a Knowledge Building Community, the knowledge of the collective is the focus. This lends a dynamic, adaptive flavor to the learning enterprise because to advance the knowledge of the group, you must first know its boundaries. New contributions by one person will influence subsequent investigations by others. Thus, individual understanding is driven forward by the dual need to be familiar with the knowledge of the collective and the desire to advance that knowledge.

The concept of a Knowledge Building Community is perhaps best understood from a sociocultural perspective. According to sociocultural theory, knowledge is fundamentally situated in cultural activity. By this, socioculturalists mean that what most people consider to be learning (e.g., the acquisition of new ideas, new vocabulary, and new skills) is more accurately viewed as knowing how to participate in different communities of practice (Pea & Gomez, 1992; Eckert, 1989). Cognition is distributed, "stretched over, not divided among—mind, body, activity and culturally organized settings (which include other actors)" (Lave, 1988, p. 1). Therefore, individual learning is not a matter of cognitive self-organization but is a matter of taking a participatory role in established cultural practices (Lave & Wenger, 1991;

Eckert, 1989). From a sociocultural perspective, the establishment of a class-wide Knowledge Building Community is an attempt to acculturate students into a community of practice that is aimed at building knowledge through sustained collaborative investigation. Unlike conventional classroom education, the goal is to turn over more of the high-level operations to the student, encourage authentic peer discourse, and emphasize understanding over memorization.

COMPUTER-SUPPORTED INTENTIONAL LEARNING ENVIRONMENTS

To support teachers in their efforts to foster classroom-based Knowledge Building Communities, Scardamalia, Bereiter, McLean, Swallow, and Woodruff (1989) have developed CSILE, a networked learning environment. Students use CSILE to build and refine a class database of text and graphics notes. Typical notes might include a question, a graphic illustrating a theory, a research plan, and a summary of information found from resource materials. Every note is public and can be examined by any member of the class. Students interact with one another by connecting their notes with links and comments, by coauthoring notes, and by engaging in online discussions. Thus, a CSILE database is best understood as a student-generated, hypermedia-based research environment that is constructed collaboratively and continually evolves (Scardamalia et al., 1992).

This CSILE software package consists of two applications that operate across local-area and wide-area computer networks (Fig. 1.3): the server, which manages the classroom database, and the client, which communicates with the server from other computers on the network. The client application, which is more commonly called CSILE, is the one that students

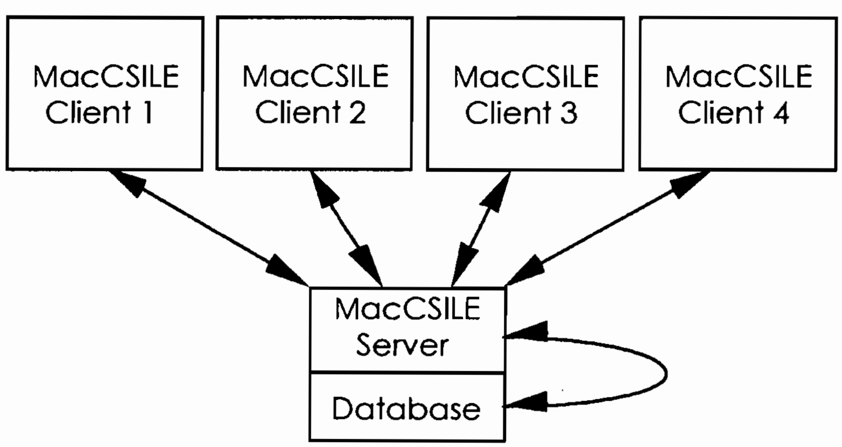

FIG. 1.3. A conceptual representation of CSILE information flow.

use at their desks. At the beginning of the year, the database is empty. Students use the CSILE client to create notes. As they complete their notes, they select Save from a menu, which automatically transmits their notes to the server, which in turn stores them in the class database. When students want to recover their notes at a later date, the server sends the notes to the appropriate client. By this method, students can access the entire contents of the database from any computer in the classroom.

The *ILE* in CSILE signifies an important aspect of CSILE's design philosophy: a focus on intentional learning. Intentional learning is defined by Bereiter and Scardamalia (1989) as, "cognitive processes that have learning as a goal rather than an incidental outcome" (p. 363). Essentially, it concerns student goals and whether or not these goals are oriented toward understanding. Bereiter and Scardamalia (1989) argue that certain activities discourage intentional learning by focusing students on the completion of tasks rather than focusing them on their own thinking. Essay writing and project work often fall into this category. Schoolwork of this sort assumes that understanding will emerge as a natural by-product of student efforts to complete their assignments. However, as discussed earlier, this does not always take place. Scardamalia and Bereiter (1997) suggest that one of the problems with task-based methodologies is that the goals of the teacher are in conflict with the goals of the student. The teacher's goal is to help the student understand the material, while the student's goal is to simply complete an assignment. Inevitably, some individuals develop strategies that are effective for task completion but yield few cognitive benefits. CSILE, as an intentional learning environment, attempts to circumvent this problem by involving students in the purposeful pursuit of understanding. It facilitates this process by providing the following supports for knowledge construction, collaboration, and progressive inquiry.

Supports for Knowledge Construction

Supports for knowledge construction include a framework to record ideas using text and graphics (Fig. 1.4), a flexible note retrieval mechanism, and tools for establishing links between notes. Using these facilities students are able to represent their ideas in the CSILE database, create connections between related notes, and view information from multiple perspectives.

Supports for Collaboration. CSILE can be thought of as a discourse medium because of the many ways in which the program promotes student interaction. The public nature of the database itself is perhaps CSILE's most significant collaborative feature. Because everyone can see everyone else's work, there arise opportunities for collaboration in CSILE that might be missed in regular classroom activities (Scardamalia, Bereiter, Hewitt, &

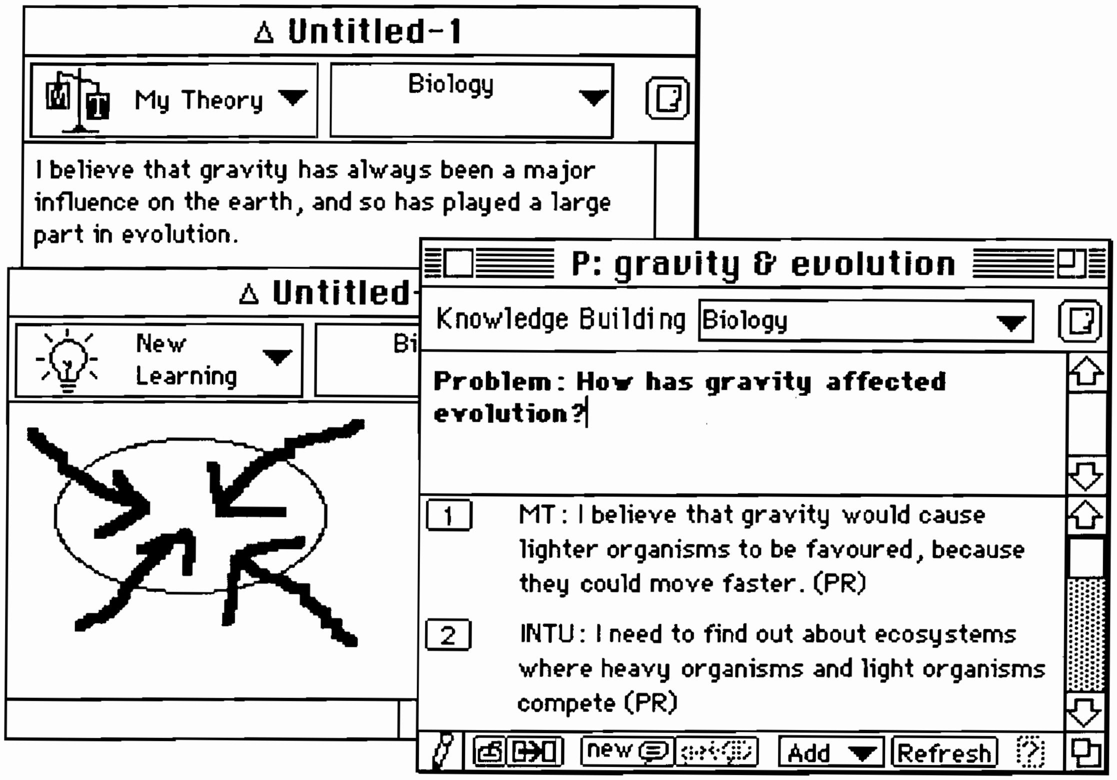

FIG. 1.4. A CSILE text note, graphics note, and discussion.

Webb 1996). In some ways, interaction in CSILE is superior to traditional groupwork because the entire class can review all exchanges. Unlike face-to-face conversation, which is transitory, computer-mediated communication preserves discourse, allowing students to return more easily to their ideas and study them from a variety of perspectives (Levinson, 1990; Mason & Kaye, 1990).

A second support for CSILE collaboration is called *commenting*. Students typically create comments when they want to share an idea or a reaction to someone else's note. A comment is a note that is linked to the note it is commenting on (called the target note). When examining a note in CSILE, students can quickly access all the comments that have been made on it and, if they wish, add one of their own. Because comments are notes themselves, they can also be the subject of other comments, leading to a comment chain (Fig. 1.5). Commenting is somewhat similar to e-mail but such comparisons do not fully capture the level of interaction that CSILE is attempting to promote. E-mail tends to involve a private exchange between two people. On CSILE, two people may (and do) exchange ideas through comments but their exchange becomes part of the public database. Thus, a more accurate portrayal of CSILE would view commenting as occurring not just to benefit the individual participants but also to advance the understanding of the entire class (Scardamalia & Bereiter, 1994).

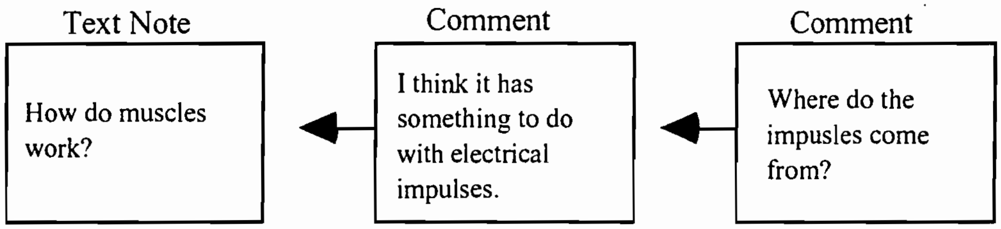

FIG. 1.5. A comment chain.

Supports for Progressive Inquiry

A key principle of CSILE's design is to bias students toward activities that focus them on cognitive goals (Scardamalia et al., 1989). To do this, a set of thinking type tags has been developed that direct learners toward particular cognitive operations. Some of the most commonly used thinking type tags are as follows:

1. *Problem (P)*: A Problem entry is associated with a note that describes a student's learning objectives. Research indicates that even children in grade six can produce and recognize educationally productive questions (Scardamalia & Bereiter, 1991a). Prompting students to identify their own problems of understanding is intended to encourage an active, intentional stance toward learning. The goal is for students to view learning as a process that they control rather than as a teacher-directed, school-specific activity.
2. *My Theory (MT)*: The My Theory thinking type is used by students to describe what they know about a problem and to suggest hypotheses. This serves both to activate their prior knowledge and to engage them as builders of explanations. Initial theories are frequently unrefined and contain misconceptions. However, CSILE teachers tend to be accepting of early, faulty attempts and encourage students to work toward revising their explanations as understanding develops.
3. *I Need To Understand (INTU)*: The phrase I Need to Understand prompts students to take a more active role in identifying problems of understanding. Members of a Knowledge Building Community are always asking more questions and looking for more information. There are no final answers, just progressively deeper explanations. INTU statements are intrinsically motivating because they develop out of the learner's own curiosity about phenomena in the world.
4. *New Information (NI)*: When students discover new information that is relevant to a problem, they record it with a New Information (NI)

thinking type. Books, CD-ROMs, magazines, teachers, parents, and peers are common sources of information. At the grade six level, the teacher provides some guidance in the selection of resource materials. However, the responsibility for extracting the relevant information remains largely with the student.

5. *What We Have Learned (WWHL)*: The thinking type What We Have Learned (WWHL) is used to summarize the advances that a group of students have made on a problem.

In summary, Scardamalia and Bereiter offer the Knowledge Building Community model as an alternative to traditional educational methodologies. In this model, the class becomes a research team that builds knowledge through sustained, collaborative inquiry. A program called CSILE supports class-wide knowledge sharing through a central, public database in which students access each other's ideas, questions, theories, and discoveries. Other CSILE tools, in the form of thinking type prompts, invoke a bias toward a more intentional approach to learning. In theory, CSILE combined with a new classroom emphasis on knowledge building should overcome some of the inefficient practices of modern-day classrooms and give students greater control over their own educational agenda.

REINVENTING THE CLASSROOM

The task-based practices of North American classrooms are difficult to overcome. Traditional school culture is continually reinforced and perpetuated by parents, teachers, curricular guidelines, and the policies of educational administrators. Consequently, reinventing the classroom as a Knowledge Building Community involves changing well-rehearsed, almost instinctive, practices and fighting upstream against the expectations and conventions of the school community.

To better understand the nature of this problem, we explore one teacher's ongoing efforts to rethink pedagogical priorities and restructure classroom routines accordingly. Two grade six Human Biology units serve as "before" and "after" snapshots of classroom activity. In the "before" unit, the teacher makes an initial effort to foster collaborative knowledge building. Although thoroughly familiar with the project's constructivist underpinnings, the teacher runs into a number of problems. By the time the "after" unit takes place (two years after the first unit), the teacher has developed new instructional strategies that bring his class much closer to the Knowledge Building Community ideal. These strategies are described in detail and the rationale for their success is examined.

Human Biology Before Trial

In the first unit, the teacher encouraged his students to work together to collaboratively advance their knowledge of human biology. He impressed upon them the need to develop good questions, help each other with their research, and advance their personal and collective understanding of the subject matter. Students were instructed to organize themselves into 10 groups, each consisting of 3 or 4 members. Every group was asked to identify a subdomain that they wanted to pursue (e.g., the heart). The teacher recommended that each student explore his or her selected area by writing at least one CSILE note for each of the thinking types provided by the software. For instance, an individual studying the heart would create one note that poses a Problem, another that provides New Information, and so on. In this fashion, the student would engage in all the cognitive activities supported by CSILE.

One of the expectations in this particular class was that students should work to publish one or more of their notes over the course of the unit. Publishing is a CSILE feature that allows the teacher to bestow special status on notes that are exemplary, or meet some predefined criteria.

> Teacher: I see my role as chiefly one of monitoring students and of assisting those in difficulty. The publishing feature on CSILE is a useful means for meeting with students to discuss their contributions. I insist that all notes, which are to be used for evaluation, must be published. To be granted the status of published, a note must be a significant contribution to the database and it must be grammatically correct. As I meet with students to discuss their notes, I try to guide them to explore more deeply into the problem they are working on. I may also suggest related or alternative approaches that they could take. Every student has individual needs and a unique style, so what is appropriate for one, might be far too difficult for another. CSILE provides an environment where it is possible to address such differences, but I have found that it is helpful to work with students on a one-to-one basis, usually while examining their work on the CSILE screen, to get the best results. (Excerpt from a note submitted to a CSILE database for teachers, 1995)

The unit lasted approximately six weeks. Each student had access to CSILE for thirty-minutes each day. All groups were provided with additional thirty-minute research periods during which they could visit the school library or examine the resource materials that the teacher made available.

Periodically, the teacher would gather the class together to discuss the groups' progress. He encouraged them to create comments on each other's work and to publish their notes as frequently as possible. As part of their grade, students were expected to help each other with their research by writing at least one CSILE comment to another person.

The results were disappointing. Although students followed the teacher's instructions it was felt that the class was still a long way from becoming a Knowledge Building Community. The following issues were identified as problematic:

1. *Lack of collaboration*: To assess the level of collaboration in the database, each note was examined to determine if it implicitly or explicitly referred to one or more other notes written by other authors. Notes that met this criterion were labeled as *collaborative*. Only 15% percent of the Human Biology notes were assigned this rating during the first trial. Of these, approximately two-thirds of the collaborative notes were concerned with superficial and low-level issues such as spelling and grammar. Thus, student interaction was infrequent, and when it occurred, it was rarely aimed at advancing knowledge.

> Allan...
> I have made this comment on your lung cancer note.
> 1. You had good English in your note.
> 2. I learned a lot that will help me in Biology.
> 3. Decent spelling could be better.
> Chris

Low levels of collaboration may have been partially due to a lack of understanding among students regarding the nature and purpose of CSILE. Students seemed to perceive the program as an environment for project-based work in which their main objective was to seek out and replicate information from texts. From that perspective, collaboration would be a secondary, less critical activity, because no one except the teacher was considered a domain expert or a reliable source of information. Indeed, although most children wrote at least one comment to one of their peers, few wrote more than one. Their goal, it appears, was to simply meet the teacher's request to write at least one comment to another student.

Another troublesome observation concerned the failure of students to respond to their peers' comments. Of the 32 comments made over the course of the unit, none of them received replies. Consequently, it is difficult to consider any of the online interaction in the Human Biology unit as genuine discourse. It is possible that low-level concerns of the comments (e.g., spelling, grammar) were partially responsible for their failure to inspire responses. Many of the comments did not warrant a reply because they dealt with surface features or because they failed to provide specific advice. Because there was no evidence of students discussing substantive issues, there was little reason for sustained discourse.

Gill,
I think your plan on biology is very good because you put the nurses office and other people didn't even think of that. And where you're going to find your information is excellent but I think you have a few spelling mistakes otherwise it's perfect.
Nancy.

In summary, a number of problems associated with student interaction were identified at the end of the first Human Biology session. Most of the notes that were rated as collaborative dealt with superficial and low-level issues. This finding, combined with the failure of comments to receive responses, suggests that CSILE was not used as a medium in which knowledge was advanced through collaborative means. It is hypothesized that students engaged in online interaction to satisfy the teacher's requirements and not out of a genuine desire to collaborate.

2. *Lack of conjectures*: Students rarely shared their theories or conjectures with others in the database. In fact, only one conjecture was detected during the entire unit:

Skin cancer is a disease people say you get from being out in the sun to long. I'm going to find out if that's true or you have it when you are born. Maybe it's a combination of both. I think some people can get it more easily than others.

The scarcity of conjectures was not completely surprising because conjecture-building was not emphasized by the teacher. However, it does suggest that conjecture-building was not something that students engaged in spontaneously. It is possible that the class did not consider CSILE to be an environment in which their opinions and ideas would be of value. Or perhaps the absence of conjectures is indicative of a more systemic failure: a school culture in which student guessing is either frowned upon or discounted. Regardless, the notes in the Human Biology database contained few conjectures, and this was a concern at the end of the unit.

3. *Weak student plans*: The plans that students generated in CSILE tended to be brief and organized around topics rather than problems of understanding. For instance, in the following note, the student seems intent on pursuing topical interests (blood cells, nerve cells, brain cells) rather than specific queries.

My plan
****
I will be working on the blood cells, brain cells and nerve cells. I will do research when ever possible.
Who I will ask
****
I will ask my parents, their friends and my friends.

This pattern was typical of notes with a Plan thinking type. None of the plans presented questions that the students thought were important to address.

Teacher: Looking back, I can see that Plan was simply a listing of topics or items which might be studied and they seemed to be, in many cases, related only in a superficial way to one another. Few plans were concerned with problems or a set of problems which might lead the students to a better understanding of a process. Also, there didn't seem to be a very definite commitment to a particular series of activities such as time spent in the library or speaking to specific people.[1]

4. *Poor Information gathering*: Students tended to examine broad areas of interest (as opposed to a specific problem). As a result, they often accumulated information about their subject area in a rather nondiscriminating fashion. The following note is a typical effort.

Cells
Cells are made up of atoms. Cells are the smallest common unit of life we study. There are about 10 trillion cells in your body right now. The cells in your body might look like something you might find in the sea or ocean. They might have tentacles or hair or even spikes. Cells can't be seen by the bare eye. You would need a really good microscope. When you put cells together you make tissues. All living things are made of cells. Some small things that live in the sea only have one cell. Bacteria is the smallest kind of cell. Nerve cells are the largest kind of cell. Some nerve cells are three feet long. The cell membrane gives food and oxygen for the cell to eat to make energy. Plant cells are bigger than animal cells therefore are easier to see. Plant cells and animal cells differ in many ways such as animal cells need oxygen to live and plant cells need carbon dioxide to live. Most plant cells can make there own sugar substance. It is made of the energy from the light and water and carbon dioxide. This substance is called photosynthesis. Each cell in your body has its own personal job. Cells

[1]Unless otherwise indicated, all teacher quotations were taken from an interview conducted in November, 1995.

> do not live very long except for brain cells which you should have for life. The jelly like stuff in the cell is called cytoplasm. The nucleus controls the cells reproduction. The blood brings digested food to the cell. Cell is a Latin word that means "a little room." The cell became known after they invented the microscope because you couldn't see the cell with your bare eye. When carbon dioxide gets near the cell, the cell will not let it in. The organelles are like our organs.

Undoubtedly, this student learned some new information about cells during this exercise and she gained experience using the classroom encyclopedia. However, there is also the sense that she has just collected a list of facts, many of which she will not retain. The text does not appear to be directly copied, but a copy-delete strategy was likely employed. There are few indications that she is making an effort to extend her own understanding.

Notes like this one are symptomatic of a task-based perspective. It suggests that students viewed their CSILE work as a collection of loosely related tasks that they had to complete for a grade. There didn't seem to be any appreciation of how these different activities could tie together and build on one another. For example, the writing of a New Information note would be interpreted as fulfilling one of the teacher's unit requirements rather than an opportunity to extend personal understanding.

5. *Too many unanswered questions*: Student questions tended to be grouped together in a single note rather than individually (see some examples below). On average, students listed approximately five questions per note. This phenomenon appears to be a process of question-brainstorming, in which students invented as many questions as they could about a particular subject area.

1. How does lung cancer form?
2. How does cancer kill?
3. Are there any preventions for cancer?
4. Are there more then one type of cancer?
5. If the answer to question 3 is yes, do all cancers kill?
6. Can cancer kill kids?
7. Are there a 100% proven cure for cancer?
8. Can you do anything to stop cancer?

1. How do you get AIDS?
2. What group of people are more in danger of getting AIDS?
3. What causes AIDS?

4. What does the hiv virus do to you?
5. What is the treatment for AIDS?
6. What are the precautions for AIDS?
7. If someone who has AIDS looks different what do they look like?
8. Why is AIDS not a laughing matter?

Notes containing lists of questions were not pivotal ones in the database. Students rarely made direct reference to their questions in the notes that followed. In fact, only once did a student refer back to earlier queries and acknowledge which questions had been addressed and which ones had not. The questions apparently played little or no role in guiding or structuring research.

In summary, there was little evidence in the first unit of online collaboration. There was also an absence of conjectures. Students appeared to view their time on CSILE as a process of fulfilling requirements for the teacher. They developed questions, conducted research, and wrote comments on each other's work, but they treated these activities as individual jobs to perform rather than as a coordinated effort to improve personal understanding. Despite the teacher's efforts to encourage a more collaborative, problem-centered classroom culture, it appeared that students were approaching CSILE from a task-based perspective.

Human Biology After Trial

Two years after the initial Human Biology unit, the teacher taught the unit again. Once again, the teacher allocated six weeks to the unit and provided each student with thirty minutes of CSILE time and thirty minutes of research time per day. However, by now he had developed a number of effective strategies for combating the task-based mentality that caused problems in the first unit. Six of these strategies are discussed here.

Teacher Strategy 1: Place a Greater Focus on Problem-Centered Collaboration. In the first Human Biology unit only 32 comments were written, a disappointingly low number. The teacher felt that collaborative processes needed a greater presence and visibility in the CSILE database. His solution was to instruct students to use CSILE in a different way than in previous years. Instead of recording ideas in separate CSILE notes, students were asked to store ongoing group dialogues in a single, coauthored note called a "discussion." Groups were told to begin their discussions with a problem of understanding (e.g., "How does the heart work?") and then progressively append their individual contributions (Fig. 1.6). Each entry was to begin

Problem: How do we breathe? (TA)

I Need To Understand: To understand some of the lower respiratory conducting tract I must know more about the trachea and bronchi.(SG)

New Information: I know that inside our chest we have something called the bronchial tree. The bronchial tree consists of the trachea, also know as the windpipe, the bronchi which is connected to the trachea, the bronchioles which are connected to the bronchi and the alveoli which are tiny air sacs at the end of the bronchioles.(TA)

I Need To Understand: I know about the positions of the parts of the lungs and bronchial tree but I still need to know about all the functions.(TA)

I Need To Understand: I need to understand what the bronchi is made of.(AG)

Comment: Dear April, while reading about the windpipe I did not find out what it is made of but I found that it is tough and flexible so that you can twist and turn your head.(TA)

New Information: While reading about the lungs and bronchial tree I found that the entire bronchial tree is a series of air tubes. (TA)

New Information: I found out that there is a muscle called the diaphragm. It is like a rubber sheet which stretches out over the bottom of the chest. When we breathe in the diaphragm flattens and makes a larger space in the lungs. Then the space is filled with air. When we breathe out the diaphragm curves upwards and makes the space smaller so the air is pushed out. (TA)

FIG. 1.6. A CSILE discussion.

with a thinking type (e.g., I Need To Understand) and end with the student's initials. A CSILE discussion thus served as a chronologically ordered record of a group's thinking about a Human Biology question.

Discussions were advantageous because they brought together the text of all participants in the same window and focused students on the same problem of understanding. The high visibility of different people's texts, combined with a shared interest in resolving a particular problem, increased the likelihood that individuals would read, and respond to, each other's work. This arrangement also allowed an entire discussion to be accessed in a single database retrieval no matter how large the conversation grew. In contrast, each note in the first Human Biology unit was a separate entity and required a separate database call to be displayed. Group work was less visible and required more time to access.

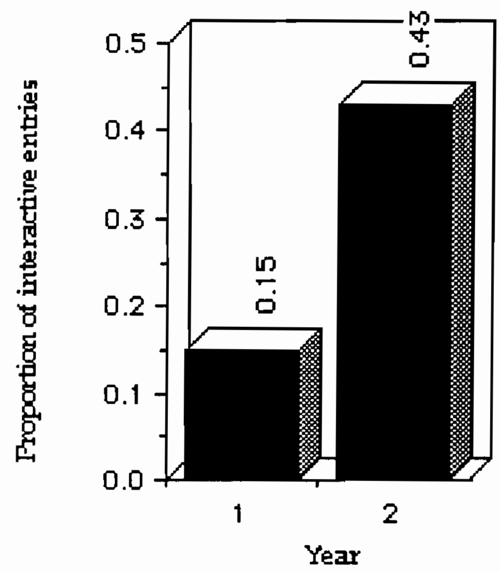

FIG. 1.7. Change in the proportion of collaborative entries.

The invention of CSILE discussions resulted in much more extensive discourse than in the first Human Biology session. The proportion of collaborative entries jumped from 15% to 43% ($p < 0.05$), a significant increase (Fig. 1.7).

Teacher: I remember thinking there was a qualitative difference in what the discussion group was doing. It was so different from the text notes, which read more like an electronic research project. The discussions seemed to engage the students in a higher level of thinking and knowledge building and writing, than I'd ever seen.

Teacher Strategy 2: Guide Students Toward Educationally Productive Queries. Since a CSILE discussion is an attempt to resolve a particular problem of understanding, it is important that students select problems that are educationally worthwhile. For this reason, the teacher often discussed the process of question-asking with students. He explained that the goal was to select a problem that was neither too broad nor too narrow, and preferably one that investigated a process. Phrases such as, "How does x work?" were provided as templates. The teacher suggested that students begin by identifying personal areas of uncertainty or confusion, and then out of that thinking, formulate an effective problem statement.

The teacher also discussed the issue of question follow-up with his class. He explained that once a question was recorded in CSILE, it was important that students make some effort to resolve it. The teacher acknowledged that in many cases the school's resources would not provide sufficient information. Occasionally, students may pose queries that even scientists have been unable to resolve. However, the important thing was to make as much progress as possible. Even after local resources have been exhausted, students should still make conjectures, ask more questions, and critique each other's ideas.

Teacher Strategy 3: Make Student Thinking Focal. Many factors may have contributed to the low number of conjectures in the first Human Biology unit. Some individuals may have felt uncomfortable speculating about unfamiliar issues. Others may not have considered theory building to be an educationally productive activity. At best, their theories would be validated by classroom reference materials that needed to be consulted in any case. At worst, their theories would reveal the depth of their own ignorance. Thus, for some students, posing conjectures may have seemed to be a futile endeavor, and perhaps even risky, because they might invite unwanted criticism.

One case that highlights the risk of conjecture building occurred during a study of prehistory. It began with a student, Lisa, who decided to share her thinking about the process of human evolution:

> I think that first there were monkeys, and they evolved into gorrillas, and they evolved into apes, and apes evolved into humans.

This inspired the following response from another student, John:

> For your information, gorrillas and monkeys are apes. And they are all still around, if you don't believe me then you can just check your local zoo.

John's first criticism, that gorillas and monkeys are apes, is partially correct. Ape is a generic term referring to primates without tails, such as the gorilla, the chimpanzee, the orangutan, and the gibbon. However, a monkey is not an ape.

John's second criticism concerned the process of evolution. If monkeys evolved into gorillas, then why are there still monkeys around? It was an interesting line of reasoning and an important challenge to Lisa's theory, but it was obscured by the tone of the message. Lisa responded to John's comment, but her response seemed to be written more in anger than as a constructive critique of his ideas:

> How do you know there are still apes around? You can't believe everything you read, you know.

It is evident from even this short exchange that posing a conjecture in a public forum such as CSILE opens students to criticism. It is much safer to reproduce information found in reliable resource materials than to invent explanations that are likely to be incorrect. It is also apparent that some students do not always phrase their comments in a completely constructive manner.

In an attempt to encourage higher levels of conjecture building, the teacher proposed the following guidelines:

1. Students were expected to use the My Theory thinking type in response to the Problem and I Need To Understand thinking types in their CSILE discussions. This guideline was intended to make conjecture building a regular and important part of the students' daily activities.
2. Students were asked to generate theories *before* they consulted any research materials. This guideline was introduced because some students gathered information from an encyclopedia and other classroom texts and misrepresented it as personal conjectures. The teacher assured the class that they would not be penalized for having incorrect information in their My Theory entries. He explained that the purpose of My Theory was to encourage students to think on their own about a problem and to invent reasonable explanations.
3. Students were asked to respond to other people's theories in a constructive manner. The teacher explained that many of the My Theory entries would contain misconceptions and it was important not to criticize others unduly for their initial efforts. Of course, it was also expected that students would work collaboratively to replace their early misconceptions with progressively better explanations.
4. Students who wished to modify a theory were not asked to rewrite it or delete it, but instead they were asked to create a new theory at the bottom of the discussion. In this way students could see how their understanding improved over time.

The teacher's new guidelines made theorizing an important part of classroom activity. The percentage of CSILE notes in the second unit rated as conjectures rose significantly to 37% from the 1% value (Fig. 1.8) of the first Human Biology unit ($p < 0.001$). The teacher felt that the new emphasis on My Theory involved students more deeply in their research:

Teacher: I think [My Theory] is really important for them because it provides a starting point, it gets them thinking in some depth about a problem. In the beginning, their theories are usually fairly brief, but if I can see a way that I can encourage that student to put more detail in that theory, I'll ask them to go

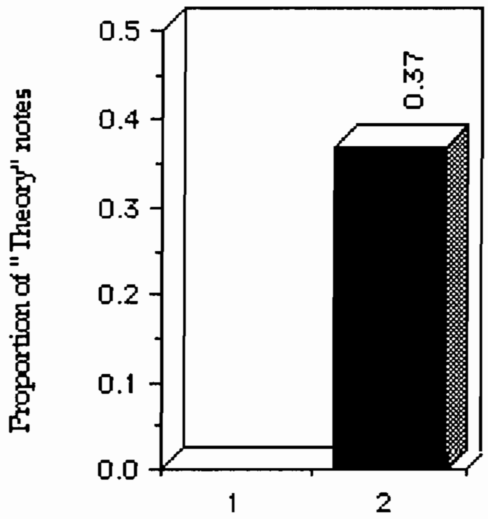

FIG. 1.8. Change in the proportion of student theories.

> back and do that. Theories give them something interesting to do the research about, they want to know whether they are right, and they'll often comment that, "In the beginning I thought such-and-such, but after doing the research I found that I was wrong," or "correct" in other cases. Theories give them a mental model to start with so they are less likely to use copy-delete and knowledge-telling methods.

Furthermore, the teacher thought that My Theory provided him with a better awareness of student beliefs and misconceptions.

Teacher: Theories are also useful because it's usually in theories that misconceptions are revealed. This gives me an idea of the direction I need to encourage in the research so that those misconceptions might be overcome. It's also just plain interesting to read and see how startling some of the misconceptions can be. Had I stood up in front in the class and taught a lesson, most times I never would have realized that the students' understanding of the basic principles, which I was taking for granted, was really much less developed, or poorly developed, than I would have thought.

Teacher Strategy 4: Make Evident the Iterative Progression of Learning. A fourth strategy shared with students during class meetings concerned the progression of CSILE discussions. The teacher suggested that there should be a sense of flow between thinking types and that online interactions should read like a conversation. To make this idea more tangible, he presented some guidelines for the selection of thinking types. He recommended that My Theory entries be employed in response to a Problem or an I Need To Understand entry. The thinking type I Need To Understand, in turn, should be created in response to My Theory (if the student is attempting to identify what is needed to advance that theory) or in response to New Information (if the student has a question about new findings). Finally, the New Information thinking type should be used to help verify or disprove a theory.

> Teacher: I try to get the students to begin working on their problem with a theory because I think it gives them an opportunity to think in some depth about possible solutions. I then think it's important for them to generate an INTU based on their theory because it sets out a direction, related to the problem, which their research can take. Otherwise, there is a tendency to persist in topic- based fishing trips in the encyclopedia or other resource material. I do spend quite a bit of time with individuals asking them what problem they're working on when they're doing their research. The answer often is, "I'm working on energy," (for example) so I take that opportunity to redirect them to a problem which they are trying to solve. I explain to them how difficult it is to find information related to a specific problem and how they will have to consult many sources before they are likely to be successful. It's another attempt to move them away from the model of source material determining the direction of research, rather than the problem determining the direction of research.

The teacher also pointed out that the research should be iterative in the sense that questions lead to theories, theories lead to new information, and new information leads to even deeper questions. Miyake (1986) notes in her study of people trying to understand the functioning of a sewing machine that the participants learned in an iterative fashion. As they gained understanding at one level, they would identify new conceptual problems at a more detailed level. They would then attempt to develop an understanding of that next level. This was the pattern that the teacher was striving for in CSILE—a progression partially evident in the discussion, "How does a cell function?" The first INTU was an attempt to clarify the first two My Theory statements. Subsequent INTUs were attempts to extend the information reported in the NI. Each subsequent query drove the investigation a little deeper (see Fig. 1.9).

Problem: How does a cell function? (AR)

My Theory: I think a cell functions by oxygen coming into the cell and the cell then can do its work by breathing. (AR)

My Theory: I agree with your theory but when the cell functions I don't think it is breathing, I think that the oxygen you're breathing in is doing it. (JD)

My Theory: I think a cell functions by the "things" inside the cell. (organelles) (AK)

My Theory: I think that the cell functions with the help of the organelles. (MS)

I Need To Understand: How does the oxygen get into the cell, if the cell really does breathe oxygen? (AR)

My Theory: I don't think that cells breathe oxygen, I just think that the cell needs oxygen to do its work. But if the cells do breathe oxygen, I think that there is some kind of a tube in the cell that helps the cell get the oxygen it needs. (AK)

New Information: I found out that the cell takes food and oxygen in through the membrane. This happens regularly. The cell then changes the food and oxygen into energy. It uses the energy to do its work. (AR)

I Need To Understand: How does the food and oxygen get to the cells membrane? (AR)

My Theory: I think there are very small tubes that lead to each cell and the food and oxygen goes down those tubes and into the cell through the cell's membrane. (AR)

My Theory: I disagree with your theory Anna, I think that the oxygen and food goes into the cell automatically as a daily process. (AK)

Comment: April, I do think the food and oxygen goes automatically as a daily process. I just think it goes automatically down very small tubes to each cell. (AR)

I Need To Understand: What the oxygen does when it gets to the cell? Note: Also need to know how the oxygen gets to the cell. (AR)

My Theory: This is what I think the oxygen does when it gets to the cell. I think that the oxygen goes into the cell through the membrane and it then goes to the nucleus where it is turned into energy. Then the cell can do its job with the help of the energy. (AR)

FIG. 1.9. An example of iterative inquiry.

By underscoring the complex, iterative nature of learning, the teacher hoped to move students beyond the simple question–answer epistemologies that tend to be fostered by the IRF discourse patterns of conventional classrooms.

Teacher Strategy 5: Encourage Substantive Collaboration. Although the teacher continually encouraged students to respond to each other's ideas, he discouraged efforts that were overly critical or lacked substance. He explained that collaborative contributions should offer new ideas or new questions that the author of the target note had not previously considered. Examples such as "I think you did a good job" and "I really like your note" fail in this regard. The notion that students should orient themselves toward knowledge advancement was frequently revisited in an ongoing effort to make them more cognizant of their role as learners and the role they should play when collaborating with peers.

Teacher: I used many different techniques to try to get students to understand the difference between low and high-level comments. I've tried to get them to write about the knowledge and/or understanding that is present in the entry that they are commenting on. I've given them cheat-sheets with suggested lead-ins, such as "I want to question your statement that. . . ." I've also spoken to the whole class and to individuals and tried to get them to see the difference between a comment based on form and a comment based on content.

Teacher Strategy 6: Stress Understanding. A common thread underlying all of the teacher's direction to his class was an emphasis on understanding. For example, with regard to the reading of resource materials, the teacher was very concerned that students not mindlessly transfer information from classroom texts into CSILE notes. He shared these concerns with his class and recommended that students not bring library books to the computer. Instead, they were asked to take notes on paper, reflect upon the new information, and then, later, express these findings in their own words in CSILE. In this way, students were less likely to adopt cut-and-paste strategies and were more likely to take an intellectually active role with respect to the new material.

Teacher: I keep reminding them that when they go to do research they should have a problem in their mind that they are trying to solve. I'll say to them, "What problem are you working on?" and I'll say, "What do you need to understand to make some progress in solving this problem?" Then I'll say, "You should read the text, try to understand what it is about. You may have to look in many different places before you can solve this problem. Just read it and think about it, and try to understand it, and if you do, just jot down some point- form notes in your research books to remind you what you learned. You shouldn't be copying out of the book, shouldn't be writing in sentences. The important thing is understanding." So, I'll say something like that, or parts of that, periodically to kids as they're working on their research.

Teacher Reflections

In the following passage, the teacher discusses his own perspectives on the changes that occurred in his classroom:

I introduced CSILE into my classroom nine years ago, and since then I have used it extensively in knowledge building activities in different curriculum areas. I use it primarily for knowledge building in science, but I have also used it for language, social science (particularly history), and mathematics.

When I began using CSILE, I relied much more heavily on direct instruction than I do now, and what the students tended to produce were individual research reports with better illustrations and better organized information, but reports which were otherwise similar to those they had written by hand. It has taken a long time to change students' approach and ideas about learning and it has not been an easy task. Now, the students' study of curriculum units probes deeper using both text and pictorial information and, with the inclusion of the commenting feature, is combined with constructive criticism of one another's ideas.

A few years ago I began using discussion notes, which were designed to encourage students to be more aware that they should be trying to construct knowledge rather than just telling (or copying) information. Discussion notes allow students to contribute to, and follow, the development of knowledge and understanding, both their own and that of their classmates. I have found discussion notes to be a very powerful means of developing students' knowledge building skills because they make it easier to follow the development of the ideas and learning over time.

Students use problems, rather than topics, as the basis of all the work that they do. These problems are usually centered on processes so that students are encouraged to build their understanding of how things actually work rather than just describing the characteristics of areas under study. It is an approach that stresses function more than structure. In my experience, students are usually oriented towards topics and telling knowledge, and often the knowledge is descriptive. Changing their way of thinking to knowledge construction is difficult and time consuming but CSILE can be an effective support in this endeavor. Most of the problems are defined by the students themselves and I have found that with practice and appropriate guidance, they are able to construct problems which can be very profitably explored by themselves and their peers. It does require some time to establish the difference between problem solving and problem-centered learning.

Overall, the major change in my own classroom has been one of approach. The locus of control has shifted from me to the student. The students have taken on much greater responsibility for their own learning. I have tried to stress to students that their goal should be real understanding rather than the production of a report or the achievement of a high test score. The student is responsible for making sound educational decisions; I am responsible for providing an environment that allows this to happen. This has not been an easy task, at least for me. I have found that by the time students are in grades five and six, they have become very skillful at the school game and they are quite adept at completing their tasks with a minimum of really deep thinking about the issues or problems being studied. Insisting that they focus on processes and develop a real understanding of how things work requires constant encouragement and support. It also helps to stress that learning is never over. Students should begin to see that it is possible to probe deeper into virtually any problem, and that the learning from one set of problems can often have applications in a different set.

I try to use this approach in all areas of the curriculum, not just in the work which the students are doing directly on CSILE. In this way I hope that the benefits of such an approach will be realized more quickly than might otherwise be the case. Some students, of course, are not mature enough to handle this kind of responsibility and then it is up to the teacher to intervene. But, in my experience, most students recognize their problems and, if they cannot solve them, they will seek the advice of the teacher or a friend.

To support this process even further, I've recently tried to increase my efforts and activities with the parents of my students, to try to get them to support the type of knowledge building approach that I use in the classroom. For example, instead of asking their child, "What did you do today?," they might ask, "What did you learn today?," "What problems are you working on in science?," "What are the learning goals for today's math assignment?," "How do you think that process works?," and so on.

In my view, training students to become familiar with CSILE should be incidental to the achievement of learning goals. But obviously, when introducing students to the CSILE system, the teacher can choose knowledge building units that emphasize a particular aspect of the program—for example, a study of biological species that requires extensive use of the graphics program.

The methods I use to introduce problem areas vary depending on the students' previous experiences and my own thoughts about students' abilities. I may give specific problems to solve but students also generate their own problems, which is a very important aspect of their work on CSILE. Sometimes my introductions are quite brief and at other times our work on CSILE follows a considerable amount of time spent on classroom activities. Often, by the second term, students anticipate the next area of study and may begin to prepare for it in advance. What I am looking for from the class is knowledge building—not copying out of books but really seeking to understand, collaboration, problem definition, substantive commenting, theory generation, and re-thinking. I adjust my expectations according to the students' abilities and to the time of year. In the fall, when CSILE may be new to many of the students, they require more direction; in the spring, each student should be able to contribute, through comments and collaboration, to the knowledge building of other students.

I'm sure there are many effective approaches to using CSILE. The following four examples are ones which I have found to be useful:

1. **To define and examine the principles on which scientific observations are based.** A recent example was a unit we did on "How Electricity Works." We carried out several class experiments, and each student wrote a report on CSILE on what was observed combined with an in-depth study (including the use of graphics notes) to come up with a model of what was occurring during the passage of an electric current through a metal or a liquid. Prior to this study I introduced the students to the concept of molecules. Group work required them to generate theories, to define areas of uncertainty needing more research, and to comment on the ideas of other students. Eventually, the class formed a single group whose aim was to arrive at a satisfactory understanding of the processes involved.

2. **To explore a problem which is both real and current.** A while ago we did a unit on "How Our Environment Is Threatened." The student groups were of varying size depending on the special interest of the members; two students were interested in acid rain, four others in the depletion of the ozone layer, and so forth. Ultimately, the groups pooled their information in CSILE's communal database, and through discussion, monitoring the database, and commenting, the students became aware of the interrelationship between the various issues and arrived at an overview of the environmental threat.

3. **To design an experiment, environment, or structure.** I have used CSILE to have students design a city or a series of experiments. There is the potential to use the graphics notes more extensively in these situations and then to provide a justification of choices in the linked discussion or text notes. It may be necessary to complete some preliminary research in a design environment on CSILE, but it is also quite appropriate to have students really think about something without referring to external sources.

4. **To create a forum for all the knowledge built around a specific problem or group of problems.** Two units where CSILE performed this function were "How the Human Body Works" and "How Evolution Works." After the students had generated an overall body of knowledge, groups explored specific problems that interested them—for example, "How is pain transmitted?" or "How are physical features inherited?" The communal database reflected the in-depth thinking of groups and individuals on specific problems and, at the same time, unified them in a common orientation. By reading and commenting on each other's notes, the students gained insight into knowledge in a way that would have been impossible in a traditional classroom.[2]

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[2]Excerpt from the PCN database, April 1995.

CONCLUSION

Transforming a classroom into a Knowledge Building Community is a difficult endeavor for many teachers because the model conflicts with conventional school practices. In particular, the traditional emphasis on completing tasks encourages a "What do you want me to do?" mentality that focuses students on products rather than on personal understanding. The difficulties in the first Human Biology session were at least partially due to a clash in expectations and values. Although the teacher provided many of the conditions necessary for a Knowledge Building Community to develop, the students were still focused on task completion. Only when the teacher made the emphasis on understanding explicit did activity patterns change.

The second Human Biology unit shows significant gains in student interaction, theory development, and the level of problem-centeredness. On average, students collaborated with more of their peers and their in-group discourse was more sustained. The thinking type My Theory was assigned to 37% of the notes, a significant increase from the 1% posted in the first unit ($p < 0.001$). Also, students pursued more of their own questions and they pursued them in greater depth. On many different levels, the class appeared to be acquiring many of the characteristics of a Knowledge Building Community.

It is proposed that the new class emphasis on discussions and theory building was fundamental in bringing about many of the aforementioned changes. What was crucial about this process was the shift away from the notion of students as knowledge gatherers toward the notion of students as knowledge builders. Using the thinking type My Theory, the teacher legitimized student beliefs, explanations and arguments as important class objects worthy of collaborative analysis. In a similar fashion, the teacher's instructions regarding the New Information thinking type encouraged a more constructivist class perspective. In the first unit, New Information was often used to replicate information found in books. Now the information was used to validate, disprove, and advance student theories. A new Knowledge Building culture was emerging, one more intent on developing explanations and refining them.

In summary, the students' initial use of CSILE was characterized by a task-based mentality in which the goal was to write certain kinds of notes. The strategies employed by the teacher in the later unit seemed more effective at focusing the class on understanding. His instructions concerning question generation, the construction and extension of theories, and the application of an iterative research methodology brought about greater levels of Knowledge Building than in his first attempt. In particular, the teacher's directives concerning the use of discussions and the My Theory thinking type appear to have been an important part of this transformation.

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