Chapter 3

Fostering Knowledge-Creating Communities

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Throughout history there have been hotbed communities where knowledge creation has taken on a life of its own. Sagan (1980) attributed the development of science to the Greeks living in the region of Ionia off the coast of Turkey 2,500 years ago. Before then, phenomena in the world were attributed to the gods, who controlled nature and often intervened in the lives of people.

> But in the sixth century BC, in Ionia, a new concept developed, one of the great ideas of the human species. The universe is knowable, the ancient Ionians argued, because it exhibits an internal order: there are regularities in Nature that permit its secrets to be uncovered (p. 140).

The first Ionian scientist was Thales of Miletus, who figured out how to measure the height of a large object from the length of its shadow and the angle of the sun above the horizon: "He was the first to prove geometric theorems of the sort codified by Euclid three centuries later" (Sagan, p. 142). Like the Babylonians, he believed the world to once have been made of water, but unlike the Babylonians he did not attribute the formation of land to a god, but rather to a process like the silting that occurred in the Nile delta. Anaximander of Miletus, a friend of Thales, was "one of the first persons we know of to do an experiment" (p. 143). By examining the moving shadow cast by a vertical stick he determined accurately the length of the year, and was the first person in Greece to make a sundial. A string of great Ionian scientists and mathematicians followed, including Pythagoras, Anaxagoras, Empedocles, Hippocrates, and Democritus.

In the small city of Cremona, Italy, during the 16th to 18th centuries, there developed a tradition of violin making that has never been equaled anywhere in the world. Andrea Amati in 1564 is credited with developing the modern shape of the violin and the characteristic amber-colored varnish

of the Amati instruments. His two sons followed him as string makers and his grandson Niccolo trained the founders of the other great violin-making families of Cremona, Andrea Guarnieri and Antonio Stradivari. The two sons of Andre Guarnieri developed their own refinements on the Amati design, and one is credited with moving the F-holes—the figures cut into the belly of the violin—further apart to improve the resonance. The most famous of the Guarnieris, known as Giuseppi del Gesu, was the grandson of Andre, but he abandoned the Amati-inspired designs for the bolder style of the Brescian school. Antonio Stradivari, who is the most famous of the violin makers of Cremona, devoted his life to perfecting the design of the violin. His improvements consist chiefly in lowering the height of the arch of the belly, making the four comer blocks more massive, giving greater curvature to the middle ribs, altering the setting of the sound holes, and making the scroll more prominent. The flowering of creativity in Cremona is a story that has many parallels in history.

One such similar story, as told by Krugman (1991), involves the development of the carpet industry in the small city of Dalton, Georgia, after World War II. The story starts in 1895 when a teenaged girl, Catherine Evans made a tufted bedspread as a wedding gift. The craft of tufting, although developed earlier, had fallen into disuse at the time, so that it was an unusual gift. The recipient and her neighbors were so delighted with the tufted bedspread, Catherine Evans began making other tufted items as gifts. Around 1900 she discovered a trick of locking the tufts into the backing, and then began selling the bedspreads. Soon she and her friends started a local handicraft industry that sold items beyond the local vicinity. The industry became semi-mechanized in the 1920s to satisfy the demand for chenille sweaters, but remained mainly an industry that was carried out by different households. After World War II a machine was developed for making tufted carpets, which turned out to be much cheaper to make than woven carpets. As the expertise in tufting at that time was centered in Dalton, many small carpet firms sprang up in and around Dalton, while the existing carpet firms that stuck to weaving went out of business. At the time that Krugman (1991) reported the story, 19 of the top 20 carpet-making firms in the United States were located in and around Dalton. In his book, Krugman detailed how other industries similarly develop in focused geographical areas.

The most famous recent story of such a concentration of industry and creativity took place in Silicon Valley. This story began when Frederick Terman, the vice president of Stanford University, decided to help William Hewlett and David Packard start their own electronics firm, Hewlett-Packard, by providing capital and setting up a research park on Stanford land. Other occupants soon followed. The Research Park became the nucleus for the growth of Silicon Valley. It created a synergistic relationship, where Stanford benefited from the proximity of the new high-technology firms that were started by its staff and students, and the firms benefited from the rich source of knowledge and personnel that Stanford provided.

Many of the new startups in Silicon Valley were spun off from the early firms that were started with Stanford support, so that it is possible to construct a kind of genealogical chart of the growth of firms in the Valley. Clearly ideas and techniques have spread easily from firm to firm, as for example the user-interface approach developed at Xerox PARC spread to Apple and then to Microsoft Windows. The strategies for supporting creativity in Silicon Valley are being widely copied in many other places (e.g., the Research Triangle in North Carolina) with greater or lesser success.

SAGAN'S EXPLANATION FOR KNOWLEDGE CREATION IN IONIA

Sagan (1980) suggested there was a combination of several factors that made Ionia a suitable site for the development of science. First, it was an island realm, which bred diversity and weak political control, which in turn supported free inquiry. "Political power was in the hands of the merchants, who actively promoted the technology on which their prosperity depended" (p. 141). Also, it was at the crossroads of cultures between Greece, Egypt, Phoenicia, and Babylonia, which "met and cross-fertilized in a vigorous and heady confrontation of prejudices, languages, ideas and gods" (p. 141). The Ionians were traders and so came in contact with all these cultures.

> What do you do when you are faced with several different gods each claiming the same territory? The Babylonian Marduk and the Greek Zeus were each considered master of the sky and king of the gods. You might decide that Marduk and Zeus were really the same. You might also decide, since they had quite different attributes, that one of them was merely invented by the priests. But if one, why not both? (p. 141).

In addition, they were the first Greeks to adopt the Phoenician alphabet, which led to widespread literacy. This meant "the thoughts of many were available for consideration and debate" (p. 141). So for Sagan the creativity of the Ionians derived from the freedom to inquire, the conflict of different cultural perspectives, and the importation of writing as a tool for thinking.

MARSHALL'S EXPLANATION FOR THE CONCENTRATION OF INDUSTRIES

Krugman (1991) described how the early 20th-century economist Alfred Marshall explained the concentration of industries in such places as Cremona, Dalton, and Silicon Valley. Marshall cited three basic reasons. First, Marshall cited the pooled market: "Employers are apt to resort to any place where they are likely to find a good choice of workers with the special skill which they require; while men seeking employment naturally go to places where there are many employers who need such skill as theirs and where therefore it is likely to find a good market" (p. 37). Second, such a center provides specialized products and services, such as hairdressers and film editors in Hollywood: "Subsidiary trades grow up in the neighborhood, supplying it with implements and materials, organizing its traffic, and in many ways conducive to the economy of the material" (p. 37). Third, information flows more easily:

> The mysteries of the trade become no mystery; but are as it were in the air...Good work is rightly appreciated; invention and improvements in machinery, in processes and the general organization of the business have their merits promptly discussed: if one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of further new ideas (p. 37-38).

Marshall argued that specialized communities develop many varieties of expertise and that this knowledge flows through the community, leading to new inventions and innovations. A close-knit community fosters expertise and refinements of products and processes, whereas outside influences and demands foster creativity. In a close-knit community there are multiple exemplars of expert practice to learn from. Hearing the latest developments and watching them unfold provides a powerful learning environment. At the same time it is necessary to understand what the outside world is thinking and to develop new ways to meet the demands and opportunities that the outside world offers.

BROWN AND DUGUID'S EXPLANATION FOR THE SUCCESS OF SILICON VALLEY

Brown and Duguid (2000) elaborated on Marshall's third point by developing an ecological metaphor to explain the success of Silicon Valley. They described the Valley as made up of a set of firms and a cross-cutting set of "networks of practice, " which link the different communities of practice

(Wenger, 1998) within each firm to the wider community within the Valley. "Networks of computer engineers, for example, will run through all the firms manufacturing computers" (Brown and Duguid 2000, p. 162). These networks of practice form the connections through which ideas and techniques move through the Valley, because the members of each network have many informal ties to each other. "Knowledge that sticks within firms quickly finds ways to flow between them, as if seeking out the firm with the most suitable complementarity. In such circumstances, as firms keep a constant benchmarking eye on each other, the ecology develops as a whole. Both invention and innovation develop rapidly and together" (p. 165). Further, they argued that "while failure is undoubtedly hard on a particular firm and its employees, it too may be beneficial for the ecology as a whole, providing useful insight into market conditions" (p. 165). They cited the failure of the firm Zilog as seeding the Valley with local-area-network entrepreneurs. Finally, they argued that living in close proximity is essential to the success of the Valley: "In the Valley, people live in and out of each other's pockets, and this helps them see what's doing, what's doable, and what's not being done. This close proximity not only shows how to attack a particular niche, it provides the ability to see a niche before it is visible to most eyes" (p. 168).

CHARACTERISTICS OF KNOWLEDGE-CREATING COMMUNITIES

These views from economics, organization theory, and history of science form a coherent picture about the conditions that lead to invention and innovation. We can synthesize these explanations into a set of seven characteristics found in knowledge-creating communities.

Sharing Ideas

In a knowledge-creating community, the air is filled with ideas and techniques that are exchanged freely, as Brown and Duguid (2000) described Silicon Valley. People are excited to share their ideas and discoveries with others. Everyone has easy access to sources of ideas, such as people and databases, and they contribute ideas to the community in various ways. Different people freely voice their opinions, and feel that they can offer ideas without fear of the consequences. Expertise develops within specialized groups, where people come to know each other's strengths and weaknesses and how to capitalize on the different strengths. They share their tacit knowledge through mentoring and apprenticeship. However, there also are information brokers who communicate across internal boundaries within

the community. People carry ideas with them as they move from group to group, which is critical to the spread of ideas throughout the community. Knowledge sharing leads to knowledge creation, because invention involves bringing together different ideas into a coherent new idea. Ideas are taken from different sources and transformed to fit the situation. Because new knowledge is created out of pieces of old knowledge, the widespread sharing of knowledge is critical to the creativeness of a community.

Multiple Perspectives

Sagan (1980) made clear how the different cultural perspectives led to creativity among the Ionians. If a community functions on its own without taking into account the ideas and demands of the outside world, it will tend to become stagnant and uncreative. Multiple perspectives foster creativity in a variety of ways. They raise questions about what is the best approach. They provide different possible solutions to problems from which the best solution can be chosen. They offer the ingredients for new syntheses. Borrowing ideas and techniques from different sources is critical to the invention process. Seeking out different sources from outside the community can foster the generation of multiple perspectives. Likewise, bringing into the community people with different backgrounds and beliefs can provoke stimulating discussion of alternative views. Rather than suppressing different ideas, it is critical to solicit different ideas within the community, so that all may be considered in devising new solutions.

Experimentation

The example of Antonio Stradivari and the other violin-making families of Cremona best illustrates the critical role of experimentation in knowledge creation. The violin makers kept experimenting with different configurations of the elements in their violin design, to see which produced the best sound. Similarly in Silicon Valley there is continual experimentation with new hardware and software ideas. Experimentation is not blind trial and error, but is based on knowledgeable reconfiguring of elements in new patterns that the experimenter has reason to think might lead to improvement. It is important to accurately assess the results of experiments, in order to make sound judgments about which innovations to keep and which to discard. Experimentation leads to progressive refinement of ideas, so that an optimal configuration of elements is achieved. But sometimes it is necessary to start over with a novel design, so that the refinement process does not get stuck in a local maxima, when there are radically different designs that might be more successful.

Specialization

In creative communities people develop different kinds of expertise that are brought together to solve problems and develop new ideas. The essence of specialization is developing deep understanding and skill in an area of interest to the person. People develop the areas in which they are most interested and capable, with the responsibility that they share their expertise with others. By developing diverse expertise, the community can deal with problems and issues that are too difficult for any individual to handle. People take on different roles in the community and each of these roles is valuable to the creative functioning of the community. As Brown and Duguid (2000) described, the different specializations form communities of practice (Wenger, 1998), where knowledge is shared and expertise is highly valued.

Cognitive Conflict and Discussion

It is from the analysis and comparison of different views that new ideas are created. The way that this kind of cognitive conflict is most productive is seen in how the Ionians dealt with the different views brought to them from surrounding cultures. Therefore, it is important that people discuss and argue about ideas without rancor or blame. Arguments must be resolved by logic and evidence, rather than by authority. Ideas are sought from many different sources, particularly ideas that challenge prevailing wisdom. Lampert, Rittenhouse, and Crumbaugh (1996) showed how it is possible to foster productive discussion among fifth-grade students to enhance their abilities to engage in productive argumentation. The students voice different ideas and approaches, and they consider these ideas and opinions in an unbiased way. Respectful listening is important to resolving differences. Discussion leads to knowledge creation by encouraging understanding of different alternatives and how they might be synthesized. Argumentation is crucial to bringing forth different alternatives to consider.

Reflection

To synthesize different views it is important to engage in systematic reflection about ways to improve processes and products. In his description of how the Ionians must have made sense of different gods, Sagan (1980) was describing the reflection process. There are a variety of ways of reflecting about new ideas. One way is to set out criteria for evaluating a particular piece of work, where the goal is to determine how things might be done better in the future. Another way to reflect is to record the process of carrying out work, to compare it to the process involved in other similar ventures. In a similar way, it is possible to compare the products of different

efforts to evaluate what are the strengths and weaknesses of each, and how they might be better. The psychological and education literature (e.g., Bransford, Franks, Vye, & Sherwood, 1989; White & Frederiksen, 1998) suggests that reflective consideration helps to recognize global patterns and relationships, which can lead to new syntheses. The pulling together of disparate elements through reflection is crucial to knowledge creation. Furthermore, if the focus is on looking for ways to make improvements, it can support process and product refinement over time.

Synthesis

The culmination of fostering multiple perspectives, argumentation, and reflection is to form new syntheses and inventions that pull together the best ideas and practices. We see this kind of synthesis in the stories of the development of natural science in Ionia and in the development of new products in Silicon Valley. When a community is faced with a problem, the solution does not usually come from a single source. Rather it is cobbled together from past ideas and ways of doing things, from different people's suggestions, from the artifacts and technologies in place, and from ideas and ways of doing things that exist in other communities. In short, communities think and respond to new situations by synthesizing new solutions from bits and pieces that are scattered around in the environment. These are all sources of knowledge that can be of use in dealing with new situations.

Our work over the past few years has focused on classroom learning communities, which are educational models focused on knowledge creation (Bielaczyc & Collins, 1999). In searching for actual examples of such communities, we looked at many different classrooms. Here we describe two settings that share the preceding characteristics, but achieve them in different ways. In both cases the technology tool these classrooms used played a large role. It has specific affordances that support knowledge-creation activities. We also found that teachers in these classrooms themselves operate as a knowledge-creating community. We examine how the mechanisms that foster knowledge creation operate in three areas: tool-based mechanisms, teacher-level mechanisms, and student-level mechanisms.

MECHANISMS TO FOSTER KNOWLEDGE BUILDING IN KNOWLEDGE FORUM

Scardamalia and Bereiter (1991, 1994) developed a model of education they call knowledge-building communities. Knowledge Forum is the name of the computer software they developed, which is used in classrooms

that may or may not have adopted the pedagogical model. The essential idea is that students work together to make sense of the world around them and work toward advancing their own state of knowledge and that of the class.

The model involves students investigating problems in different subject areas over a period of weeks or months. As students work, they enter their ideas and research findings as notes in a communal knowledge base. The goal is to engage students in progressive knowledge building, where they continually develop their understanding through problem identification, research, and community discourse. The emphasis is on progress toward collective goals of understanding, rather than individual learning and performance. Scardamalia and Bereiter (1991, 1994) provided the Knowledge Forum environment with a set of seven mechanisms designed to foster knowledge creation among students.

A Public Forum

As the name suggests, Knowledge Forum is built around a public space where ideas are shared among the whole community. Thus the core of Knowledge Forum embodies a basic mechanism to support sharing of ideas. Sagan (1980) put the introduction of writing at the center of the development of science in Ionia. The permanence of the written medium allows members of the knowledge creating community to go back and reread notes, whenever they are confused, or come upon a related idea, or want to cite evidence to support an idea they are developing. By writing their ideas for everyone to see, students participate in a community of ideas. The public forum is designed to provide a place where ideas are visible for everybody to see, so that they can be reflected upon and improved. Knowledge Forum thus enables students to be creative together, but they do not all have to be in one place at the same time. Students can work together to experiment with new ideas, and think and read and communicate with others in an extended discussion over time and space. As students find answers to their questions, they add information to the Knowledge Forum database, so that others can read and learn from them, and even question the reliability of what they added.

Scaffolds

Built into the Knowledge Forum are a set of scaffolds that support students in the inquiry process. The scaffolds address major parts of the process, encouraging students to articulate their theories, formulate their questions, identify things they need to learn, and so on. Thus the scaffolds embody major steps in the inquiry process. The scaffolds and the investigation cycle

they embody encourage students to push deeper into any topic. This encourages the development of specialized knowledge, so that students come to be experts in particular domains. Thus when questions arise that call on their expertise, they can work with others to share their knowledge and experiment with novel ideas and solutions to problems.

Build-ons

Discussion and argumentation are fostered by the build-ons embodied in the Knowledge Forum design. Build-ons are designed for students to elaborate on what other students have written. These elaborations might consist of discussions of ideas that others have developed, or conflicts with what is claimed in a note. These elaborations then can serve to clarify ideas or develop new ideas. In both cases discussion is moved forward toward deeper understanding of issues and development of new ideas.

Quotation

Students are encouraged to read others' notes and quote from them. When they quote from another student's note, the quotation appears in italics and a reference is made automatically back to the note that is quoted. The quotation feature encourages students to discuss other students' ideas and make arguments supporting or contradicting their ideas. This fosters both synthesis and reflection on ideas.

Views

By putting notes into different views, it is possible to organize the knowledge in different ways. For example, a knowledge base about dinosaurs might be organized according to the different species, the time sequence in which different types of dinosaurs developed, or the place where their fossils were discovered (Scardamalia, 2004). Thus, the different views allow for multiple perspectives on the domain. This allows students to see how ideas are related to each other from different perspectives, which supports deep understanding and synthesis of ideas.

Rise-Above Notes

The Rise-Above notes are designed to have students pull together the ideas that different students have written about. This synthesis process forces students to reflect on how different ideas are related and how they can best

be integrated. At the same time they must consider whether the notes contradict each other and whether some of the information in the notes is wrong. Thus Rise-Above notes foster integration from different sources and synthesis of new ideas.

Publication

When students feel a note makes an important contribution to the collective knowledge base, they can propose the note for publication. This requires that students reflect on their notes and select those that make the most important and creative contributions. An editorial group and the teacher then decide whether to publish the note. At the end of the school year the class may decide on a selection of notes to remain in the knowledge base for classes that come after them.

In the two schools we have looked at, knowledge creation occurred at two levels: among the teachers and among the students. It is striking how the teachers themselves functioned as a knowledge-building community. In both cases they worked to create knowledge about ways to support and improve the functioning of the students' knowledge-building communities. Similarly, at the student level a variety of mechanisms were employed to help the students function as a knowledge-building community. We first consider a middle school in the midwestern United States and second an elementary school in Toronto, Canada, associated with the Ontario Institute for Studies in Education where Scardamalia and Bereiter work.

MECHANISMS FOR KNOWLEDGE BUILDING AT WHITMAN MIDDLE SCHOOL

The first author worked for 2 years with a sixth-seventh-grade team of teachers and students from Whitman Middle School, a small suburban school in the midwestern United States. The four teachers on the team had worked together for several years, and specifically with Knowledge Forum for more than 8 years. The teachers describe their main educational objective as fostering a "learning club," where students view themselves as members of a classroom community whose goal is learning to learn. The first author became interested in working at Whitman because these teachers had sustained their use of Knowledge Forum over 8 years with very little external support. They had also been continually experimenting with ways to help their students in working with Knowledge Forum, and were recognized as innovators by other Knowledge Forum teachers. Beginning in the spring semester of the sixth grade year, she made classroom visits

approximately every 6 weeks for a period of 5 days, and collected data from classroom observations, written and online data, and interviews.

The Whitman team had four classrooms of roughly 25 students each, with each teacher specializing in one subject matter area: math, science, language arts, or personal development. Also each homeroom teacher had his or her own class for reading and writing, in which students had many opportunities to develop their individual writing processes and were encouraged to express their thoughts in their own voice. Students moved from one classroom to the next, and hence one subject to another, over the course of a school day.

Each day, on a rotating basis, one teacher would host the Knowledge Forum work. When students came to the designated class, they would spend the 50-minute period working on the Knowledge Forum research unit, rather than the usual subject matter curriculum. Students conducted their research using books from the school and public libraries, ordering relevant videos, searching the Internet, and interviewing experts where possible (through interviews out in the community or bringing specialists into the school). Students gradually learned to manage their own time during the Knowledge Forum period: conducting their investigations offline or working in the Knowledge Forum database.

The four classrooms of the Whitman team had eight computers each for student use, so all students in the designated Knowledge Forum period were able to work on the database at will, sometimes by going on their own to another classroom. Although students worked on their Knowledge Forum research on a class-by-class basis throughout the day, the learning community that the Whitman team worked to build spanned all four classes. The Knowledge Forum database contained the work of all students, and the groups that formed (described later) were based on common interests across all students, rather than within classes of roughly 25 students. The sets of possible interests were chosen from topics determined by the district curriculum.

Over the seventh grade school year, students used Knowledge Forum to support the following research units:

- Fall Term: Global Understanding. Student investigations focused on countries from around the world. Students studied questions such as these: What are important matters that affect how people live and work? How does my country connect with other countries in that region?
- Winter Term: World Religions. Student investigations focused on six major world religions: Buddhism, Christianity, Hinduism, Islam, Judaism, and Taoism. Students studied questions such as these: What are the basic beliefs set forth in this religion? How do the beliefs compare to those of my classmates and me?
- Spring Term: Astronomy and Technology. Student investigations focused on various aspects of either astronomy or technology. Stu-

dents studied questions such as these: Why do the planets revolve around the Sun? What is the history of the automobile?

Each central research topic was divided into subtopics (e.g., Global Understanding was divided into countries of the world), and students were matched to subtopics based on their top three choices. Most students were matched with their first choice. Each research unit lasted roughly 8 weeks.

Knowledge Building Among the Teachers at Whitman

The four teachers at Whitman functioned as a team, exchanging ideas and supporting each other as they learned to incorporate Knowledge Forum into their teaching. In the middle schools of the district each team had team planning time as well as an individual planning time. There were a number of mechanisms that the teachers at Whitman employed among themselves to function as a knowledge-building community.

Reading Group

Even before the teachers started working with Knowledge Forum, they formed a reading group where they read papers describing Knowledge Forum and its use in different classrooms. The teachers each kept a journal, and would discuss what they had read, and share their emerging thoughts with their team members. They would then discuss different approaches that they might experiment with in their classes. The reading group provided many different perspectives, which formed the basis for them to work out the logistics of how they might use Knowledge Forum. It also gave them the opportunity to share ideas about the kind of culture they wanted to create in their classrooms and the strategies they would use to create a knowledge-building culture among their students.

The Summer Institute

Each year the team attended the Summer Institute for Knowledge Forum that was held in Toronto. There they shared ideas with other teachers who were using Knowledge Forum and talked with the research group at the Ontario Institute for Studies in Education (OISE) that had developed Knowledge Forum. Many of the different perspectives they picked up at the Summer Institute found their way into their classrooms, so that they were continuously renewed as they experimented with different ways to use Knowledge Forum and help students identify their individual ways of learning.

Teaching Experiment

Each time the team taught using Knowledge Forum, they would try different approaches. Sometimes they would have students work on their investigations for several weeks before determining common threads to form teams, and other times they would start the students off working as inquiry teams. Sometimes they would have students put together summaries of what they learned, and other times they would develop a culminating event to support integration of the ideas. By constantly experimenting the teachers could reflect on what teaching strategies worked best, at the same time allowing the students to explore different ways of working in Knowledge Forum.

Researcher Meetings

After the first author had worked with the teachers for a year, they began a series of meetings after school or on Saturday to reflect on their teaching practices. They would often discuss strategies that were used by teachers at other schools, sometimes looking at videos of the practice in other schools to reflect on these strategies in comparison to their own teaching. They also watched videos of interviews with their own students explaining what they thought about learning with Knowledge Forum. These sessions provided the teachers with a forum to reflect on their teaching approach in the light of data from other sources.

Presentations

Finally it is important that the teachers presented their work around Knowledge Forum to other teachers in the state and, in some cases, across the country. By trying to articulate what they were doing and by answering probing questions by other teachers, they were forced to reflect on and synthesize their practice to address the challenges that come with exporting an innovation like Knowledge Forum.

Knowledge Building Among the Students at Whitman

The teachers at Whitman developed a number of mechanisms to foster creativity among students. We briefly describe the different ways that they tried to challenge students to work with knowledge in inventive ways.

No Notes Permitted

When students did research on a topic, such as Buddhism, they were not permitted to use notes from their research when they were writing their entries in the Knowledge Forum database. This was designed to prevent students from copying out what they found in books into the database. Students had to synthesize their own understanding of the topic they were writing about and characterize in their own words what they had learned. They were encouraged by the scaffolds in the system and by the teachers to develop their own theories and questions, and to pursue them through reading and discussions with other students and adults. The emphasis was on students creating their own understanding and expressing it in the tentative voice of a learner rather than repeating the words of an author.

Teaming

Students were grouped in different ways to work on their inquiry. For example, when students created the database on world religions, they were organized into teams of five students, and each team studied one of the six religions. On each team the students were assigned to five different roles (or communities of practice): historian, anthropologist, journalist, politician, and theologian. These roles formed the basis for secondary teams that would work together on specific questions about the interrelations between the different religions (e.g., what the relation is between the origins of the different religions). By working in this jigsaw fashion (Aronson, 1978), students brought ideas from different sources to their online and offline discussions, much as Brown and Duguid (2000) described among the networks of practice in Silicon Valley. This led to more discussion between students and making connections to related ideas (Bielaczyc, 2001).

Interviewing Experts

After students had worked on their research for a while, the students would enlist different "experts" to come to their classes and talk about a topic they were studying. So, for example, a number of people from the community who had special knowledge about each of the religions came to the class to talk and answer questions from the students. By bringing in different views, the students are exposed to multiple perspectives that they must synthesize to create a coherent understanding of the topic.

Mini-lessons

The teachers gave "mini-lessons" to discuss with the students strategies for carrying out their investigations. This typically involved projecting parts of

the Knowledge Forum database on a large screen to discuss issues about the student work. The goal was to show students how to dig deeply into topics and pursue questions that arise in their work. These lessons were critical to students learning how to become specialists by engaging in inquiry to deepen their understanding. Sometimes students would be invited to reflect on an important moment of learning in an entry, such as a time when they realized their theory had been wrong, or when a question was raised that pushed their investigation ahead.

Discussion Notes

To synthesize their knowledge, groups of students would work together to create discussion notes addressing some specific question. For example, one discussion note raised the question, "Is there a common link between all religions?" To address such a question, the students had to reflect on what they had learned about all the different religions. Thus discussion notes forced students to bring together the multiple perspectives and the specialized expertise that different students had accumulated in the course of their investigations.

Reflection Notes

As the end of a unit approached, teachers encouraged students to reflect on their journey of learning over the unit. Students would think about their original interest in the topic and what in their background led them to this interest. Entering their ideas in reflection notes, they would continue to describe what questions were first raised, theories that directed their search, further questions raised along the way, how their ideas changed, who helped them, times their knowledge was challenged, and other highlights during the study. The reflection notes ended with the raising of more questions, for others interested in this topic or for a student's own future learning.

Culminating Events

At the end of a unit of inquiry there was often a culminating event. For example, in the unit on world religions, the teachers organized a "peace conference" at a 1-day retreat for the students (Bielaczyc, 2001). At the peace conference, mixed groups of students who had studied different religions met together to develop sets of principles that they thought would promote world peace. Then the groups convened to develop a final set of principles based on votes of all the participants. This culminating event encouraged the students to reflect on what they had learned about the different religions,

to address a novel problem for students; that is, to synthesize universal principles that might lead to world peace.

MECHANISMS FOR KNOWLEDGE BUILDING AT THE INSTITUTE OF CHILD STUDY

The Institute of Child Study (ICS) is a laboratory school associated with the OISE, which is part of the University of Toronto. As a laboratory school, it is not required to teach all of the standards that are specified in the Ontario Curriculum, although the teachers at the school do attempt to cover the topics specified in the Curriculum. Several years ago two of the teachers in the school started using Knowledge Forum in their teaching: one teacher in a fourth-grade classroom and one in a fifth-and sixth-grade classroom. Because of the proximity to OISE where Knowledge Forum was first developed, they had strong support from the Knowledge Forum research team.

In the 1999–2000 school year three experienced teachers, who had recently joined ICS, agreed to join the other two teachers working with Knowledge Forum. One of the two teachers who had worked with Knowledge Forum in previous years became a teacher-researcher, who supported the other teachers in the project. So there was a group of four teachers using Knowledge Forum, a teacher-researcher supporting them, and a researcher from OISE who worked with the school to help them learn to use Knowledge Forum. One of the new teachers was a first-grade teacher, and this was the first time Knowledge Forum had been used at that level in the school. The other three teachers taught third, fourth, and fifth and sixth grades.

Knowledge Building among the Teachers at the Institute of Child Study

The group of teachers and researchers at the ICS functioned as a knowledge-building community during the course of the year. There were a number of mechanisms that the group employed to foster knowledge creation among themselves (Caswell, 2001; Lamon, Reeve & Scardamalia, 2001; MacDonald, 2001; Messina, 2001; Moreau, 2001; Reeve, 2001).

Reading Group

The teachers and researchers read a number of articles together that gave them different perspectives on the notion of knowledge-building communities and how they can be created. After discussing these articles, they experimented with ways to implement the ideas in the articles into their classrooms. The group met throughout the year and talked about the successes

and the problems they were having in implementing Knowledge Forum in their classrooms. These sessions provided an ongoing forum in which to bring up new ideas and discuss what was working.

Teacher-Researcher

The teacher-researcher had used Knowledge Forum for a number of years, so that he was not only technically proficient in the uses of Knowledge Forum, but he also had a wealth of knowledge about effective practices in using Knowledge Forum. He therefore could share ideas with the teachers and provide the kinds of support that they needed as they began working in this new teaching environment.

Experimentation

The group adapted methods from other programs such as the Fostering a Community of Learners (FCL) program (Brown & Campione, 1996) to try out in their classrooms. In particular they modified the "reciprocal teaching" and "crosstalk" procedures from FCL to fit into the Knowledge Forum environment. They collected data on the students from tests and interviews, and systematically reflected on their successes and failures (see later). By experimenting with different ideas and discussing with each other how they were working, the group was able to progressively refine their teaching strategies.

The Summer Institute

Like the teachers at Whitman, the team attended the Summer Institute for Knowledge Forum that was held in Toronto. There they shared ideas with other teachers who were using Knowledge Forum. The different perspectives they picked up at the Summer Institute also found their way into their classrooms, permitting them to experiment with new ideas for teaching with Knowledge Forum.

Calendar of Inquiry

Each teacher used Knowledge Forum as a personal journal to reflect on their teaching and to pose problems they were wrestling with (Reeve, 2001). Both the teacher-researcher and the researcher associated with the group read the journals and discussed with the teachers how to address problems that arose and refine their ways of teaching. The calendar acted to signal problems to the researchers, so that they might meet with the teachers to help them deal with any issues that arose.

Video Journal

To help the teachers reflect on their teaching practice, they made records of class sessions using video (Moreau, 2001). This enabled the teachers to look back on their teaching and study their teaching practices. In this way, they could identify problems, think about different ways of dealing with issues that arose, and systematically reflect on their teaching practice. It also provided a record of how their practice was changing over time, which enabled them to write about the change process in adapting to this new environment.

Knowledge Building Among the Students at the Institute of Child Study

Over the course of the year the teachers and students developed a number of mechanisms to foster knowledge creation among the students. There was a progressive refinement that occurred by which the teachers slowly turned over more and more control to the students. We can best trace this process in the fourth-grade classroom (Messina, 2001), where the teacher had decided to use Knowledge Forum to teach about light, which was part of the Ontario fourth-grade science curriculum. The teacher first broke the 22 students into three groups of seven students, who rotated through the activities of reading materials about light, carrying out hands-on experiments, and working in the Knowledge Forum database. Initially, all students worked in a Knowledge Forum view titled: "What is light and where does it come from?" As the year progressed the teacher moved from this approach, which he referred to as a factory model of teaching, to a specialization model, and from there to a knowledge-building community model. In the course of this progression, there were a number of "inventions" that he and his students came up with to foster creativity among the students.

Varied Topics

The teacher at first had students all working on the same set of issues. However, the students complained that they were all adding the same materials to the Knowledge Forum database and that the groups of seven students they had were too large to work with easily. He realized that to foster more creativity among the students he needed to break them into smaller groups that worked on different topics. So he worked with the groups to develop a set of six different topics, such as "sources of light," "images," and so on. This gave the students more ownership of what they were learning, and at the same time, he allowed the students to flexibly arrange the time they worked and experimented on the different aspects of light. This

change marked the transformation from the factory model to the specialization model for the teacher.

Crosstalk

When the teacher broke the students into smaller groups that worked on specialized topics, he introduced a variant of crosstalk, derived from the FCL program (Brown & Campione, 1996). Crosstalk is a procedure where groups of students share their ideas and progress across groups. At these sessions the students discussed their knowledge advances, their experiments, and their problems of understanding with the other students. Sometimes the other students could help explain ideas that a group was having difficulty with. These crosstalk sessions were a valuable tool for sharing ideas among the different groups.

Glossary and Teaching Notes

The teacher found from his analysis of student journals that the students were not reading notes outside the group in which they were working. Therefore, he became concerned that the students were not sharing what they learned about each topic. In a crosstalk session one of the students suggested that they develop a glossary and write teaching notes to help synthesize and explain the knowledge they were gaining to the other students. This was another attempt to increase the sharing of knowledge among all the students.

Light Learnings View

Even with the addition of the teaching notes and glossary, the large number of notes on the screen discouraged students from reading other students' notes. In another crosstalk a student suggested that they use the Rise Above notes to clean up the clutter and bring the key ideas into one coherent view. They decided to label this view the "Light Learnings View" and it was meant to be a synthesis of everything the different groups had learned. They also added new scaffolds to support group learning such as "Our understanding of X" and "What we still need to know." By organizing their knowledge into this new view, students were forced to synthesize the most important knowledge they had gained. It was at this point that the teacher felt they had moved to a knowledge-building community model, because their individual journals showed that they were integrating and organizing their knowledge to reflect the group learning. As the teacher said, "Knowledge did not seem to exist only in the minds of the students, but was something tangible that could be improved upon and/or given to new uses—used

to help in the collective knowledge advancement of the class" (Messina, 2001).

Teaching Kindergartners and Parents' Night

There were two events that helped the students reflect on all their knowledge about light. First, at the invitation of the kindergarten, the fourth-grade students put together a program of experiments and explanations of light phenomena. By teaching the kindergartners, students were learning how to make the ideas clear and accessible. Second, near the end of the year, the students invited their parents for an evening, where the class put on a play that included many of their ideas about light and provided posters that embodied the ideas in their Light Learnings View. The students became the teachers and their parents the students.

All of the classes at the ICS have adopted many of these practices. In one case, the 8- and 9-year-old students taught Saturday classes at the Children's Museum in Toronto as part of the museum's hands-on learning program for 2- to 7-year-olds. Parents' Night has been adopted as standard practice among all the classes at the school. For example, one teacher held a garden party, where students instructed their parents using some of the methods employed by the students to learn about gardens and worms, such as creating a garden on land acquired by the school. Basically, the parents took part in a Knowledge Forum session themselves, led by the children. These parent information sessions allow parents to see what gains their children have made by observing their understanding and participation in the communities' goals.

CONCLUSION

The classrooms at the two schools we have described have created environments that embody many of the characteristics we identified in the creative communities where important innovations have been spawned. The teachers at the two schools went out of their way to seek out multiple perspectives by reading and discussing scientific articles describing related innovations. They also attended workshops where teachers and researchers came together to discuss implementation issues surrounding Knowledge Forum. By working with a group of colleagues, they could develop strategies for their teaching, experiment with new approaches, and discuss their successes and failures. This argumentation and sharing of ideas was critical to refining their approaches to teaching with Knowledge Forum. Finally, they made efforts to reflect on their teaching practice and to synthesize the best approaches to teaching based on the data they collected.

Similarly, when working with students, the teachers fostered student creativity in a number of different ways. They encouraged students to specialize in particular areas and share their ideas with other students. This enabled students to gain deep understanding of the topics they studied, which they then taught to others. Furthermore, the students sought out expertise from books, experiments, and outside experts, which brought many different perspectives that the students tried to resolve by discussion and argumentation in Knowledge Forum. By combining their collective knowledge into discussion and teaching notes, they were forced to reflect on their learning and synthesize the knowledge they gained. Finally there were a variety of culminating events, from a peace conference to Parents' Nights, that fostered synthesis and using knowledge in novel ways.

The current move toward a global village is reminiscent of Ionia. People from a wide variety of backgrounds are coming together to share ideas and create new innovations. The classrooms discussed in this chapter show how it is possible to create environments that prepare students to enter into the kinds of knowledge-creating communities that are arising in the global village.

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