DOCUMENT RESUME

ED 419 789 SP 037 953

AUTHOR Caswell, Beverly; Lamon, Mary
TITLE Development of Scientific Literacy: The Evolution of Ideas in a Grade Four Knowledge-Building Classroom.
PUB DATE 1998-04-00
NOTE 25p.; Paper presented at the Annual Meeting of the American Educational Research Association (San Diego, CA, April 13-17, 1998).
PUB TYPE Reports - Descriptive (141) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Biology; *Computer Uses in Education; Cooperative Learning; *Elementary School Science; Elementary School Students; Foreign Countries; Grade 4; Intermediate Grades; Knowledge Level; *Science Education; *Scientific Literacy; Teaching Methods
IDENTIFIERS Canada; *Knowledge Development

ABSTRACT

This study describes cognitive and social aspects of children's development of scientific literacy in a Schools For Thought (SFT) classroom. SFT is an educational reform project that applies cognitive research about the active, reflective, and social nature of learning into classroom practice. Participants were fourth graders from a university-affiliated laboratory school. Researchers focused on the 1996-1997 school year, which was the school's first introduction to CSILE (Computer Supported Intentional Learning Environment) and SFT. They also highlighted the 1997-1998 year, with the new version of CSILE: Knowledge Forum. The school year science focus was biology, specifically the Giant Madagascan Hissing Roach. Beginning with sustained investigation of the cockroach, students progressed into studying adaptation, evolution, learning, and perception. Development of their scientific thinking became visible via the CSILE/Knowledge Forum technology. Data analysis included videotapes of students working, student interviews, students' written work in CSILE/Knowledge Forum, and students' research journals. Researchers examined the changing nature of the social construction of knowledge across the SFT years and in comparison to the unit conducted in the previous year. Students were very successful in their learning. The use of CSILE and Knowledge Forum provided support for students' thinking and learning, and motivated students to write. Students became experts in their areas of interest. The progression of students' thinking led many along paths similar to those of scientists working in the same areas of study. (Contains 11 references.) (SM)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 419 789

Development of Scientific Literacy: The Evolution of Ideas In a Grade Four Knowledge-Building Classroom

Beverly Caswell

Teacher, Institute of Child Study, OISE/UT

Mary Lamon

Researcher, The CSILE Project, OISE/UT

Paper presented at Session 35.32

at the

Meeting of the American Educational Research Association

San Diego, April, 1998

SP037953

Inquiries concerning this paper should be addressed to: Bev Caswell@tednet.oise.utoronto.ca

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY

B. Caswell

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

- This document has been reproduced as received from the person or organization originating it.
- Minor changes have been made to improve reproduction quality.
- Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

ERIC

2

Abstract

This study describes cognitive and social aspects of children's development of scientific literacy in a Schools for Thought type classroom. The subjects in this study are grade four students from the Institute of Child Study, a laboratory school affiliated with the University of Toronto. The study focusses mainly on the 1996-97 school year which was the school's (and teacher's) first introduction to CSILE and SFT and on the 1997-98 school year and the use of the new version of CSILE: Knowledge Forum. References are also made to the previous year in which no computer technology was used. Beginning with a sustained investigation of the Madagascan Giant Hissing Cockroach (the children took care of and studied 11 cockroaches over a 10 week period) students progressively moved into an investigation of adaptation, evolution, learning and perception using aspects of a curriculum framework originally developed by Brown and Campione (1994). The development of students' scientific thinking became visible with the use of the CSILE/Knowledge Forum technology and their ideas progressed from simple and naive understandings to deeper understandings and quite complex experiments that were initiated, designed and carried out by the students. An analysis of videotaped sessions is used along with students' written work in CSILE/Knowledge Forum and in their research journals to examine the changing nature of the social construction of knowledge across the SFT years and in comparison to the unit conducted in the previous year.

Development of Scientific Literacy: The Evolution of Ideas in a Grade Four Knowledge-Building Classroom

Beverly Caswell, Mary Lamon
Institute of Child Study, Ontario Institute for Studies in Education/University of Toronto

This study describes cognitive and social aspects of children's development of scientific literacy in a Schools For Thought type classroom. Schools for Thought(SFT) is an education reform project designed to apply cognitive research about the active, reflective and social nature of learning into classroom practice. The idea is that learning environments in which children are given multiple opportunities to reflect on their ideas, compare perspectives and become aware that they are constructing knowledge as a group as well as individually can foster extraordinary learning for all students (Lamon, Secules,Petrosino, Hackett, Bransford & Goldman, 1996).

The subjects in this study are grade four students from the Institute of Child Study, a laboratory school affiliated with the University of Toronto. The study focusses mainly on the 1996-97 school year which was the school's (and teacher's) first introduction to CSILE (Scardamalia, Bereiter, McLean, Swallow & Woodruff, 1989) and SFT and on the 1997-98 school year and the use of the new version of CSILE: Knowledge Forum. There will also be reference to the pre-SFT year (1995-96). During the SFT years, the classroom teacher (Caswell) worked collaboratively with researcher (Lamon) who had expertise in SFT implementation.

The school year science year focus was biology, and the Giant Madagascan Hissing Roach was selected as an entry point because a unit had been created previously around this species, and children find the strangeness of this particular type of cockroach both interesting and awe inspiring. The species is ancient in evolutionary terms and the story of its survival leads naturally to adaptation and evolution which are central concepts for understanding biology. Beginning with a sustained investigation of this cockroach (the children took care of and studied 11 cockroaches over a 10 week period) students progressively moved into an investigation of adaptation, evolution, learning and perception using aspects of a curriculum framework originally developed by Brown and Campione (1994). The development of students' scientific thinking became visible with the use of the CSILE/Knowledge Forum technology and their ideas progressed from simple and naive understandings to deeper understandings and quite complex experiments that were initiated, designed and carried out by the students.

Throughout the year, children were videotaped working with the teacher, working with peers, working with grade one students, and I interviewed each student. In this paper, an analysis of the videotapes is used along with students' written work in CSILE/Knowledge Forum and in their research journals to examine the changing nature of the social construction of knowledge across the SFT years and in comparison to the unit conducted in the previous year.

Curriculum Outcomes

Canada's new Science Curriculum document (Common Framework of Science Learning Outcomes, 1997) outlines four skill areas required for scientific and technological inquiry. The four skill areas are as follows: initiating and planning, performing and recording, analyzing and interpreting, communication and teamwork.

Students in the grade four classroom were given an opportunity to become immersed in the culture of scientific inquiry, and to do it in such a way that would keep them motivated. We wanted our classroom to operate similarly to the way the scientific community operates at the University of Toronto's Zoological Department. Learning investigative skills became a by-product of students' in-depth research.

Our unit of study took place over an 8 to 10 week period. Students worked on science for approximately one to one and a half hours per day, three days per week.

This extended amount of time enabled students to delve deeply into the subject area. It gave them time to think about questions, and to experiment with a variety of materials in order to test their theories.

METHOD

Introducing Cockroaches, CSILE and Personal Research Journals

The students were introduced to CSILE and to the cockroaches in the same session. We thought it was important to introduce specific activities such as writing in CSILE, reciprocal teaching, and taking research notes on a need-to-know basis. This in itself is a variation on a theme in SFT. Often, children are introduced to activities in their own right, practice those activities and then apply them. But if we want to keep focussed on ideas, it seems important to introduce activities *as ways to improve ideas.*

Students gathered in a circle on the carpet to meet the roaches and to hear a brief explanation of the insect's defence mechanisms : the two pronatal humps on the thorax which give the appearance of two fierce eyes, and the insect's ability to make a loud hissing noise. Then, in partners, students took turns either holding or sketching the insect. Half of the class drew on paper, while the other half drew on the CSILE, using computer graphics. Many of the students had never used graphics on the computer, and it was very surprising to see how rich and detailed the students' drawings were. The ability to add or change colours also kept the children very interested. After their drawings were complete, a hangman type game was played to help the children learn the scientific names in order to be able to label parts of the roach.

We also gave each child their own research journal, which we told them was what scientists at the Zoological Department used. These would belong to the students, would not be checked for spelling, and would be used to jot down observations, questions, research notes, and experiment designs.

Right away, a flurry of writing took place.

Students' Observations

Children have a remarkable ability at this age for making acute observations. While the students were drawing , they talked excitedly about their observations: "They've got little white suction cups on the bottom of their feet!", "The antennae has about 20 sections in it!", "They can sort of stretch, like an accordion.", "Its body looks all soft and white underneath, but it's got a hard shell on top." Terms like 'exoskeleton' were introduced now by the teacher as the need arose. The scientific name for these roaches, *Gromphadorhina Portentosa* , was introduced at this point and a chant was created which included some roach facts:

Gromphadorhina Portentosa
Is a giant hissing roach
Gromphadorhina Portentosa
Slow and steady in its approach.

Gromphadorhina Portentosa
Something you will want to hold
Gromphadorhina Portentosa
Likes the warm and not the cold.

Gromphadorhina Portentosa
Prehistoric to modern time
Gromphadorhina Portentosa
With their sticky feet they climb.

Gromphadorhina Portentosa
You will see them in grade four
Gromphadorhina Portentosa
From the Madagascan shore.

These types of activities seemed to make the scientific language come easily to the students, and eventually, they constructed their own chants and songs.

Question Generation and Research Groups

The group met for a **cross talk** session to discuss their observations, and this sparked further discussions and questions from other members of the class: "I wonder what the antennae are used for?" , If they've got suction cups, I wonder if they can walk on the ceiling?", "What are those two pointy things at the back of the roach?" (cerci). Already, some students were offering theories. It seemed as though question asking within CSILE was the natural next step to support this scientific thinking. During the next days, students entered one or two pressing questions into the database. Questions ranged from, "What kind of food do they prefer?" to "What did cockroaches evolve from?" And because these questions were stored in the database, each child's question could be "heard" and resources could be gathered to support a child's pursuit of knowledge in a particular interest area. The students also found it very exciting to be adding notes to build up the database. In the course of a week 100 new notes had been entered!

After the students entered their questions on the database, we could see that the questions were falling into specific categories. Here were the research groups, formed like they would in a scientific community - through the interest of the researchers. Each year, the categories would change. For example, in 1996/97, the research groups were: external anatomy, internal anatomy, behaviour, reproduction, ecology and evolution. In 1997/98, the students were interested in: perception, learning, communication, evolution and anatomy.

Research

Often, a benchmark lesson would be presented to the whole group. This might include an experiment that either responded to some of the questions on the database, or that had crowd appeal (such as the experiment which showed the male cockroach's aggressive behaviour). Students would then write on computer or in their lab books the thinks that surprised them or that they were puzzled about.

At this point, the classroom set up was such that students rotated in small groups during which time they had an opportunity to work on CSILE, conduct library/Internet research, conference with the teacher and so on.

Because there are few texts written about cockroaches for young students, we used primary sources written by and for zoologists. We introduced reciprocal teaching strategies(Brown & Campione) to children at this time so that children could help each other understand these difficult texts.Again, the need drove the introduction of the activity.We did not pre-train children on RT before exposing them to texts.

After each research session, we would meet as a whole group to discuss what had been learned that day, or what surprises we found in the research materials. These

ERIC

cross-talk sessions acknowledged the importance and excitement of learning, and let the whole class feel as though they were valued members of a team working toward gaining knowledge and understanding about these insects.

Language Arts

Sometimes we would work as a class to change the words of a song so that it became a song about cockroaches. The whole class would make up words for the chorus, then the research groups would spend 10 minutes coming up with new verses that reflected their new learning about the cockroaches:

CUCARACHA COCKROACH (by the Great Grade 4's at ICS)

I'm Cucaracha Cockroach from the Madagascan shores
I have an exoskeleton that protects me when it pours.
I was born in the lab of U of T
My brother and my sister nymphs were there with me.

We've been here for over 300 million years
We've hissed our way through all sorts of fears.
My hiss is horrible, but I'm not bad.
But when you touch my cerci I get really mad!

I arch my back and ram, ram, ram.
I use my thorax to flip enemies on their backs.
Because I'm fighting for my territory
Is it instinct or hereditary?

I breathe through my trachea
My stomach's called a crop
My brain is called ganglion
And I've got a lot!
My fat body stores carbo's and stuff
Cut off my head and I'll still live because I'm tough!

When I feel air breathing down on my cerci
Then I know someone's after me!
So I head for my nearest log-house tree
Where me and my buddies are happy and free.

I'll eat everything that I can find.
My antennae will search until they die.
I'll go in your house and steal some food
To bring back to my little nymph dudes.

When we're in the wild, we eat rotten logs.
But when we're in the lab, we eat the food of dogs.
Our antennae sense lots of food
When we don't get food for a month we get in a bad mood.

This was another way that students could show their new learning and keep each group informed of other group's progress.

Designing Experiments

One of the things that really sparked the design of experiments was our weekly visits from the grade one class, our Special Friends. When they came to visit the roaches, groups of children teamed up to build structures for the roaches to live and/or play in.

Soon they were creating mazes and one of the first experiments was a food preference test where the Ecology group set up a maze with three exits, each exit holding a different type of food. Another experiment was the one described below:

[1] MT: Experiment........
1. make a long maze with walls.
2. make a path of oranges through the maze.
3. put a roach at the start of the maze.
4. observe

5. after do the same experiment but without the oranges.
6. observe. (ad)

[2] C: very interesting. I sould try it (mg)

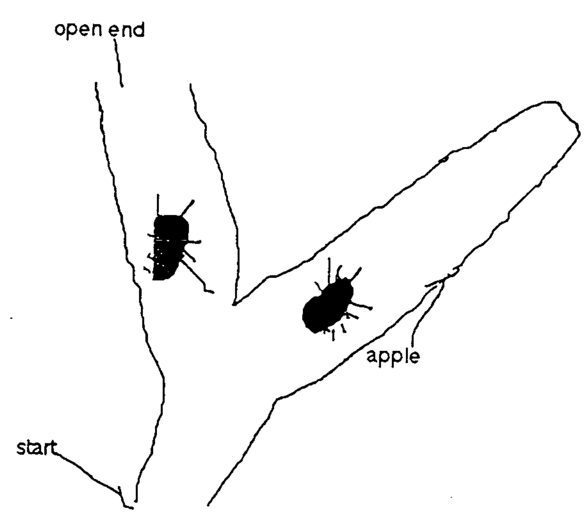
[3] INTU: Do you think that the cockroach will learn the path through the maze after one try or will it take him a few tries? (ML)

[4] MT: Today Elliott Iona Amy and our little special friends were doing an experiment.
What we did is we made a path that went two different ways.
At one end there was food and at the other end there was no food at all.
The first time we only put one cockroach into the maze and they went for the end with no food.
We did that afew times.
Then we tried to put in two roaches.
What happened was the cockroach who had been in the maze before went the same way.
But the other cockroach went for the food.
So, the cockroach who went for the EXIT went "hay" where are you going, so he followed the other cockroach to the food. If you want to see a diagram of this experiment called the "Y maze exp't" then go to it under the behaviour notes. (ik)

[5] WWHL: today(thursday.dec.12.)me(Amy) Iona and Elliot

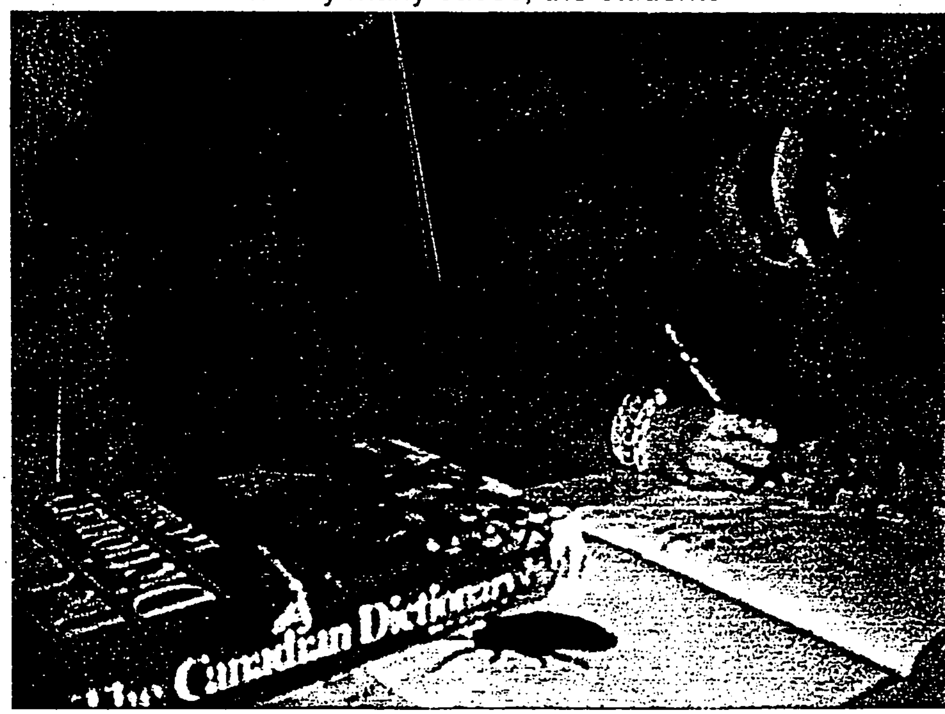
Authors: elliot allen
Topic : Behaviour
Status : Draft
Last modified : Dec 16, 1996 (15:38) Note #: 315

Elliott's y maze experiment



It was important for the students to have building materials on hand, because through their play with these materials, they began to form design ideas for future experiments.

On the computer, students were planning or describing their experiments, building on each other's notes with new information or more questions, and the knowledge base was rapidly growing. Now we introduced the **jigsaw** approach to knowledge sharing(another SFT implementation), where one member of each research group formed a new group with individuals from each of the other research areas so that everyone was able to get a view of the "bigger picture". If any questions arose from this session, students did further research and if anything couldn't be answered, they now were able to write to an expert at the lab. Rather than just write a question, we had the students describe what their question had grown from and then the students wrote down their prediction or theory about an answer. In very many cases, the students' theories turned out to be correct.



Lab Visit

Next we actually visited the lab, where we watched a dissection and looked at the wide variety of roaches that are studied there. There was a persistence with which the students questioned the experts. They weren't satisfied with superficial answers. They didn't seem to want just the "show and tell" approach, they wanted more of a 'let's discuss our findings and pursue our interests together" approach.

Each student had become somewhat of an expert in a specific area because enough time was given to think about that area of study and to experiment and develop her/his thinking and learning in that area. Now students talked to the scientists from a point of knowing and sharing information rather than merely being the recipients of someone else's knowledge.

Sharing Knowledge: the Cockroach Documentary

A primary feature of most SFT implementations is the consequential task. The consequential task as originally defined by Bereiter and Scardamalia was meant to convey the idea that children's knowledge building should be of some consequence not only for the individual but for the community. As used in SFT, the term has acquired the meaning of creating a public display of knowledge - a research report, a play, etc. Often the nature of the consequential task is specified before children begin their investigation. The grade four children themselves came up with the idea of sharing their knowledge with a wider audience. The idea of doing a cockroach documentary came up because the students kept saying things like, "We know a lot about cockroaches. How can we let other people know how much we know?" The urgency with which they asked made its importance realized. How does a scientist like David Suzuki share his knowledge with the world? And the idea of the cockroach documentary was born. There was great excitement among the students about this idea, as each research group planned how they would present their work. The reproduction group decided they would ask the lab for a female roach and film an experiment "live". The internal anatomy group wanted to use the film of the cockroach dissection then add plasticine models for further descriptions. They wanted it to be exciting, "like City TV".The Ecology group would set up their food experiments to film. them.The evolution group decided to write a script, dress up like scientists and have a combination of fact and humour. Motivation was high, and all they needed from us was help editing their scripts and showing them how to use the camera. Most of what they needed to write their scripts was easily accessible from our CSILE database. The documentary brought a nice closure to this unit of study.

DISCUSSION

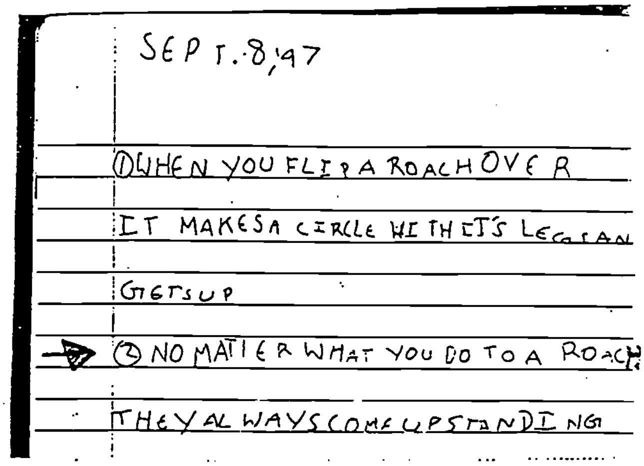
Evolution of Ideas

The following case studies of research groups show the progression of students' learning from their initial observations of the cockroaches to their final experimental designs.

Case 1: Can Cockroaches Learn? The Learning Group 1997/98

This question was developed after the initial observations by a number of students:

Excerpt from student's lab book:

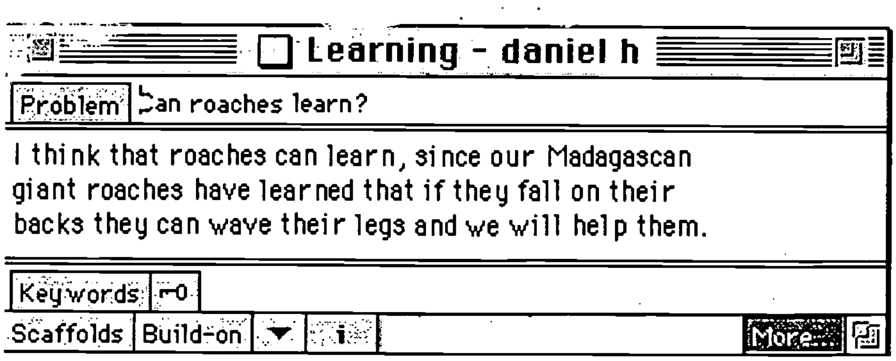

SEPT. 8,'97

① WHEN YOU FLIP A ROACH OVER
IT MAKES A CIRCLE WITH IT'S LEGS AN
GETS UP

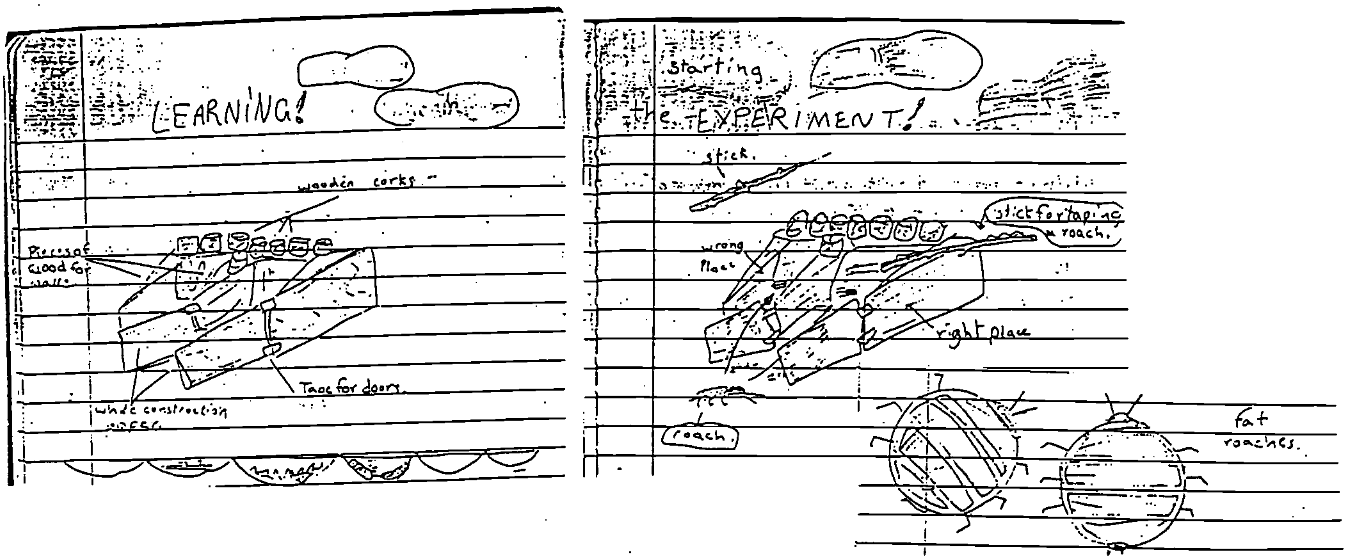
② NO MATTER WHAT YOU DO TO A ROACH
THEY ALWAYS COME UP STANDING

The teacher then showed an experiment from Dr. Bell's laboratory using stopwatches to see how quickly roaches were able to right themselves. Students tested each roach and recorded times.

About a week later,the same student writes in Knowledge Forum that he's noticed that the more the roaches are handled, the less quickly they right themselves. His theory is that they have learned to wait for students to flip them back over. He then poses the question: Can a roach learn?



He then teamed up with two other students who were also interested in the roaches' ability to learn. They did this teaming up initially through the use of Knowledge Forum. Then they met as a group and designed an experiment which involved building a structure with two chambers and two entrance ways.



ARIS' learning of roaches - aris

Problem: Roaches learning of danger.

My theory: is that cockroaches can learn, but slowly. New information: I made an experiment with a roach, what I did was I made two rooms with wooden blocks and I taped two white peices of cardboard paper on the edges to make two doors. This experiment was supposed to prove that roaches can learn.It did prove that roaches can learn.

Keywords: learn

Scaffolds | Build-on | More...

Roaches Can Learn - daniel b.

Problem: Roaches learning of danger.

My theory: is that you are right that roaches can learn. And I think you have a very good experiment. But how can your experiment proof tha roaches can learn?

Keywords: learn

Scaffolds | Build-on | More...

When the experiment began, one of the students wasn't comfortable with tapping the roach when it didn't enter the right door. Here is the conversation that followed:

Student #1: "OK, how about if we put something they like in door number one."

Student #2: "OK, let's try that."(*They ask around the classroom for pieces of grape or apple.)*

Student #1: "But how do we know the roach isn't just going in that door because he smells the apple?"

Student #2: "Oh, yeah, you're right. Well, how about we just give it the apple if it goes in the right door?"

Student #1: "OK, that might work."

They place roach outside the structure. Roach moves its antennae, but doesn't move.

Student #1: "Why isn't it moving? Maybe we should tap it."

Student #2: "No, we can't touch it, remember?"

(*Roach makes move toward Door #1*)

Student #2: "It's moving, it's moving! Oh no, it's going into door #2."

Student #1: "Oh, well, let's just give it the apple if it goes in any door."

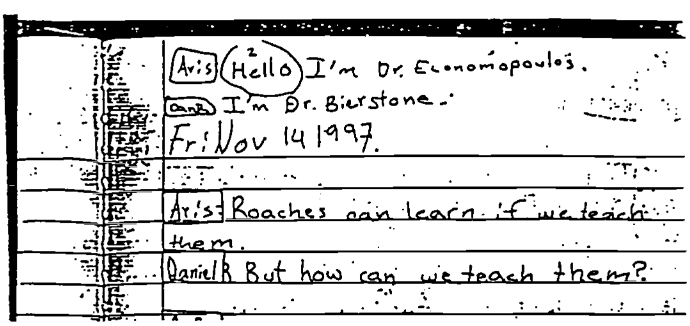
Student #2: "Yeah, and then we can see if it goes back to that same door."

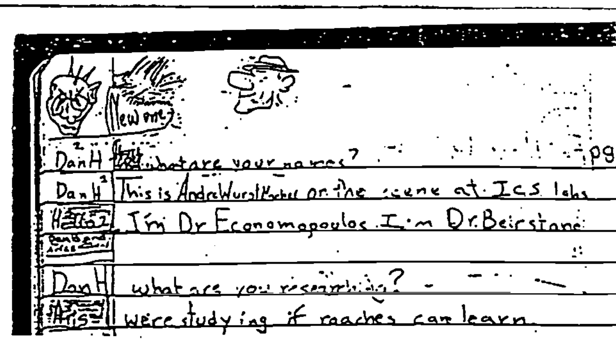
Student #1: "OK."

Roach goes in door #2. Students give it apple, then repeat experiment with same roach which goes back in door#2.

Students test three more roaches and conclude that roaches can learn.

The following is a copy of the Learning Group's script for the cockroach documentary, taken from one of the student's lab journals:


Aris Hello I'm Dr. Economopoulos.
I'm Dr. Bierstone.
Fri Nov 14 1997.
Aris Roaches can learn if we teach them.
Daniel B But how can we teach them?



Dan H what are your names?
Dan H This is Andre Wurst on the scene at ICS labs
I'm Dr Economopoulos I'm Dr. Beirstone
Dan H what are you researching?
Aris were studying if roaches can learn.

Student 1: We've made a structure with 2 rooms and 2 doors.

Student 2: We are trying to train the roach to go into door #1.

Student 1: Yes, you see, we give a reward to the roach if he goes into door #1. Then we test him again later to see if he remembers the reward and chooses door#1 again. Over time, the roaches can learn to go into the right door.

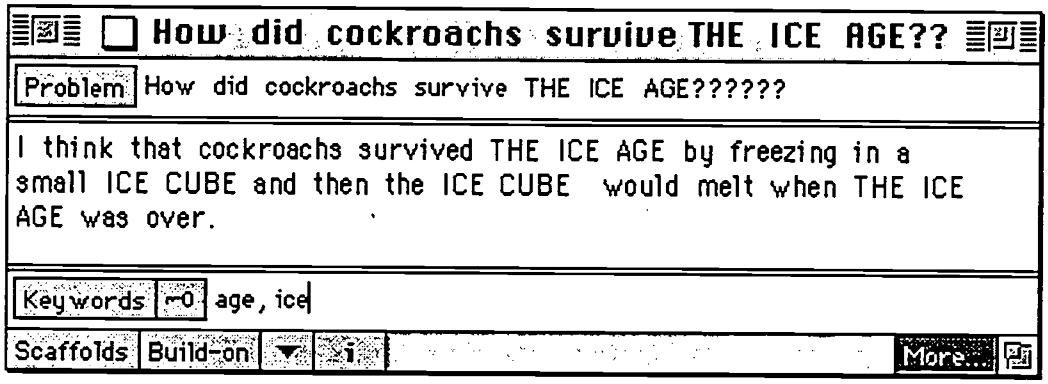
Student 3: What is your opinion on whether roaches can learn?

Students 1 & 2: Yes, they can learn!

BEST COPY AVAILABLE

Case 2: The Evolution Group asks, How did the Madagascan Roaches survive the Ice Age?

One student read somewhere that roaches survived the Ice Age. This made her curious. She writes:


How did cockroachs suruive THE ICE AGE??

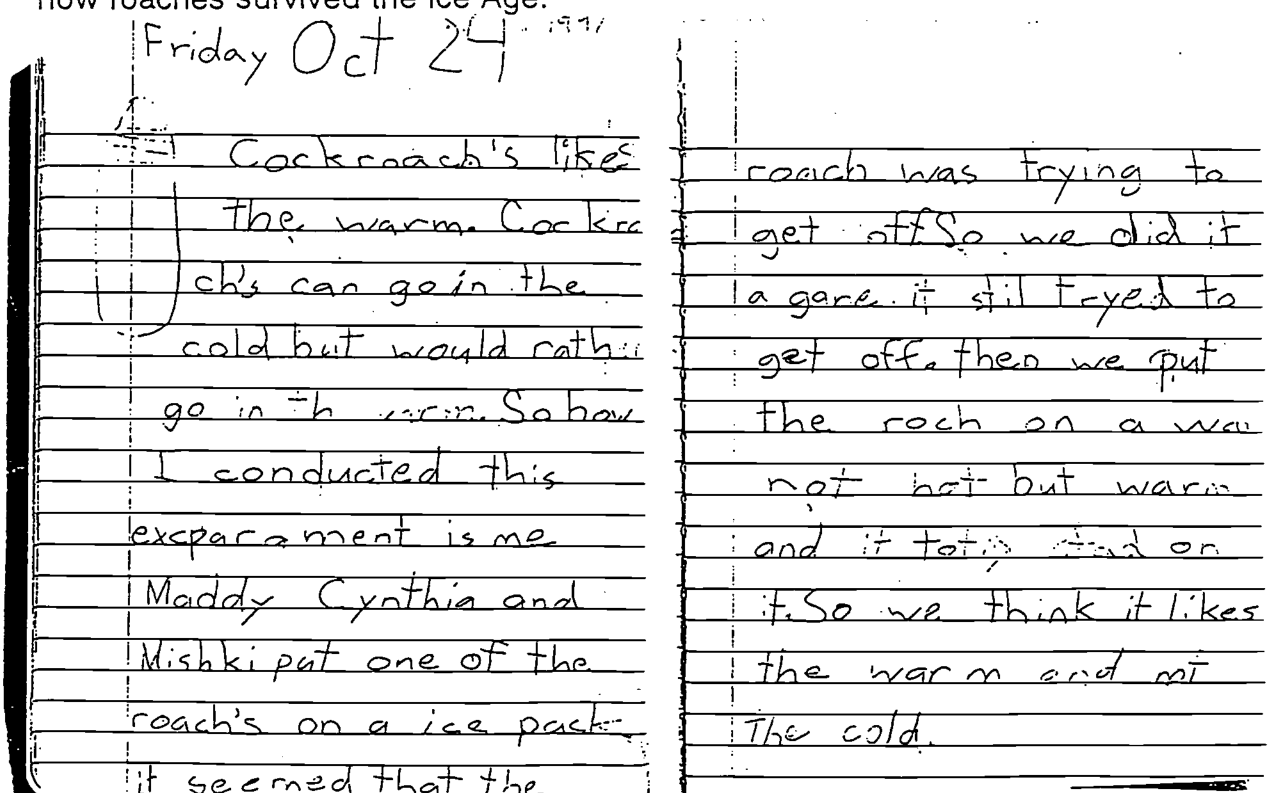
Problem How did cockroachs survive THE ICE AGE??????

I think that cockroachs survived THE ICE AGE by freezing in a small ICE CUBE and then the ICE CUBE would melt when THE ICE AGE was over.

Keywords age, ice

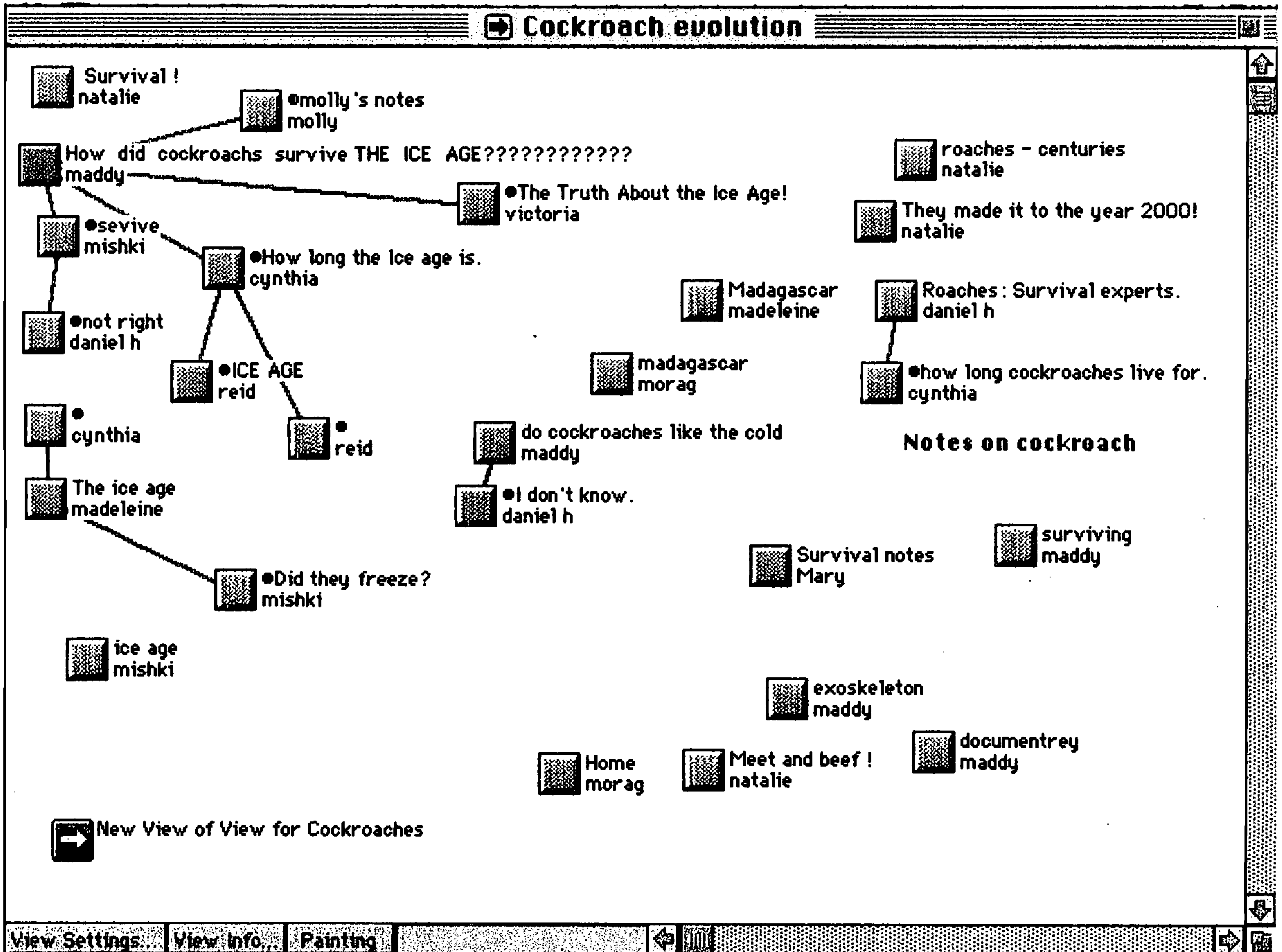
Scaffolds Build-on More...

Next, she teams up with other interested students and plans an experiment to find out how roaches survived the Ice Age:


Friday Oct 24 1997

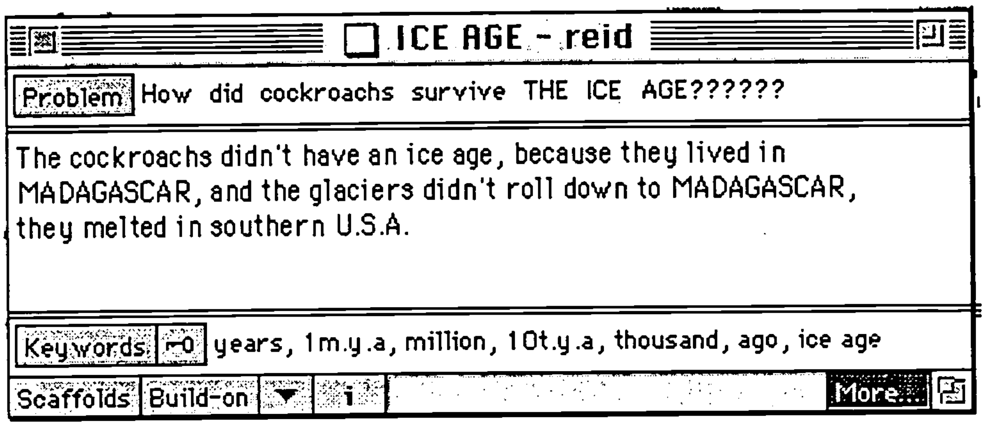
Cockroach's likes the warm. Cockra ch's can go in the cold but would rath go in th warm. So how I conducted this expacament is me Maddy Cynthia and Mishki put one of the roach's on a ice pack. it seemed that the roach was trying to get off So we did it a gare. it stil tryed to get off. then we put the roch on a wa not hot but warm and it to st on it. So we think it likes the warm and not The cold.

She concludes, "Cockroaches don't like hot areas, they like room temperature."



BEST COPY AVAILABLE

Later, she and her group did some research on the Ice Age, then we invited a graduate student in to do a benchmark lesson on the Ice Age. The next day, Mishki writes,

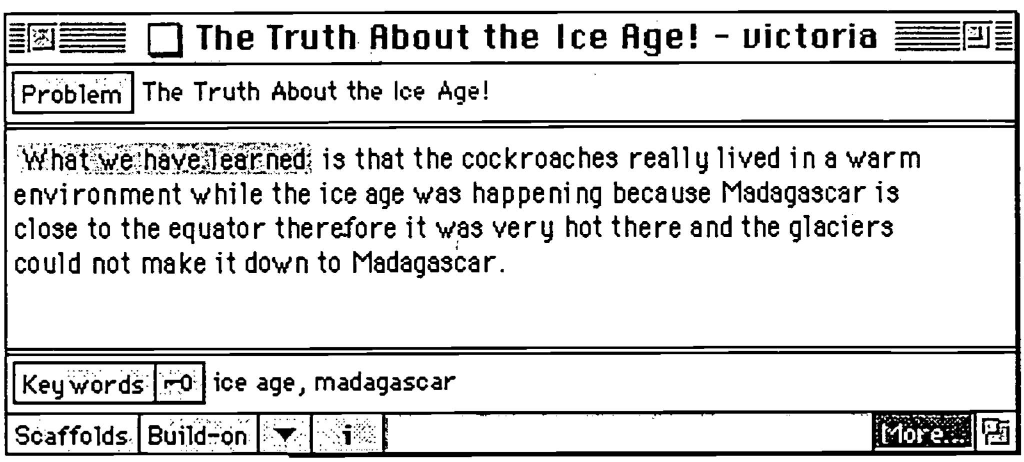

ICE AGE - reid

Problem How did cockroachs survive THE ICE AGE??????

The cockroachs didn't have an ice age, because they lived in MADAGASCAR, and the glaciers didn't roll down to MADAGASCAR, they melted in southern U.S.A.

Keywords years, 1m.y.a, million, 10t.y.a, thousand, ago, ice age

Scaffolds Build-on More...


The Truth About the Ice Age! - victoria

Problem The Truth About the Ice Age!

What we have learned: is that the cockroaches really lived in a warm environment while the ice age was happening because Madagascar is close to the equator therefore it was very hot there and the glaciers could not make it down to Madagascar.

Keywords ice age, madagascar

Scaffolds Build-on More...

seuiue - mishki

Problem: How did cockroachs survive THE ICE AGE??????

I think maby that cockroach's could have also servived the ICE AGE by maby like not frees but they could have adapedid to the cold.

Keywords: ice age

Scaffolds | Build-on | i | More...

not right - daniel h

Problem: How did cockroachs survive THE ICE AGE??????

This theory cannot explain

Unfortunetly, roaches don't have much body fat, so your theory isn't very right

Keywords

Scaffolds | Build-on | i | More...

How long the Ice age is. - cynthia

Problem: How did cockroachs survive THE ICE AGE??????

New information

There has been several Ice ages that humans know about but the most resent Ice age was from 1 m.y.a.(million years ago) to 10t.y.a.(thousand years ago)

Keywords: years, 1m.y.a, million, 10t.y.a, thousand, ago

Scaffolds | Build-on | i | More...

DISCUSSION

Differences between pre-SFT and SFT years

During the pre-SFT year, there was a similar excitement with students about having the roaches in the classroom, but without the depth that we quickly began to see during the SFT years. In the pre-SFT year, the teacher recorded students' observations, questions and theories on large chart paper. The use of a technology such as CSILE/Knowledge Forum was like having someone in the class who heard all the interesting things kids were saying and organized them nicely for the teacher to view. it was then possible to see the direction students were heading, what areas of research they needed and what further resources were necessary for these students to support their studies.

Another difference was that a researcher with extensive experience in SFT implementation was in the classroom regularly which provided in-service training and learning for the classroom teacher. In the pre-SFT year, the teacher designed all the experiments(from reading university level roach study texts), made nifty worksheets with roaches on them, experiment forms with charts that students could fill in and remembers being quite surprised at how the students weren't as excited as she was to fill these forms out. They enjoyed watching the experiments and calling out what was happening, but they didn't want to have to write about what happened during the experiment. Reflecting on that experience: "Now I realize that I had unwittingly been trying to train my students into becoming mere observers. Maybe that was why they resisted. At the end of that year, the students' science binders were at varying degrees of disarray. Some were missing many of the roach pages, others were out of order and mixed in with our snow study and energy study pages. There was no evidence of the intentional learning that was so evident in the SFT years. With the use of CSILE/Knowledge Forum, ideas are saved and can be built upon, revised and have the potential of evolving into something quiet complex."

Students' Writing

Perhaps the most visible difference is in the amount of writing that occurred with students during the SFT years. In a comparison of the actual number of words written per child between the years, the results are shocking. During the pre-SFT study of roaches, the actual number of words written by grade four students (gathered from their science binders) ranged from the lowest number of written words which was 30 to the highest which was 200. During the SFT years, in the students' lab books alone, the lowest number of words written was 70 and the highest 400. Add to this the amount of words written by the students in the CSILE database and the words comprising their documentary scripts and the results are at least 5 times higher.

Summary

What factors contributed to the students' success in learning?

1. Having a researcher in the classroom - Mary has worked extensively with children in SFT settings. She knew the deep principles of the domain, saw the 'big picture' and recognized a child's thinking in that direction and could ask the right questions to keep the thinking moving. Also, the researcher provided in-service training to the teacher(learning by doing). How can it be made possible to give more teachers the benefit of a researcher in the classroom?

2. The use of technology (CSILE and Knowledge Forum) provided support for students' thinking and learning as well as motivating the students to write. This public forum along with students' personal science lab books made a huge difference in the amount of writing that occurred compared to the year where the students had only a science binder to store their work. For one thing, students could go back into the database time and time again to read over their peer's work, revise their own work and make contributions that would move learning forward. This could not be achieved when students have only their own science binders tucked away in their desks.

3. Allowing students to become "experts" in their interest areas provided them with the time to gain understanding of the subject area.

4. Teacher's in-service training allows for gaining experience in a SFT approach to the classroom: learning how to trust the child's ability to come up with important questions, to develop theories and to design experiments to test these theories.

5. Introducing activities opportunistically seemed a more meaningful and authentic way to use these learning strategies.

Problems Encountered

1. Time needed to go through database/how to ensure each child is contributing.

2. How to deal with children unwilling/unable to express ideas on computer (or anywhere) - one solution we found useful for certain children was to actually type for them, let them tell us their ideas. For many of these students it was the fear of not spelling correctly. After entering three or four notes for these children, they were capable and willing to go on independently from then.

3. How to help certain children move from direct copying, to putting into own words, to building on to a theory or questioning an existing theory.

4. What to do about the child who gets a "free ride" in group setting - hangs out with group, but doesn't make many contributions. Balance between support of students' ideas and providing enough structure for those who need it to keep their thinking and learning progressing.

Conclusion

It has been interesting to see that the progression of students' thinking led many of them along paths that were similar to scientists working in the same areas of study. For example, many groups came up with experiments that were designed by Dr. Bell's laboratory in his roach study. Another example is the learning group designing their Skinner-like box.

The nature of a child's curiousity seems to give the child motivation, confidence and ability to solve difficult problems and questions that have occurred in her/his own mind . This ability to persist and pursue, to build and rebuild, to push for understanding, provides evidence of scientific thinking that seems to draw on an innate, exploratory and inquisitive nature. A question that requires further exploration: Is there a set sequence of developmental steps through which students progress to reach deep understanding?

In Canada, a new science curriculum has been launched which has as its vision the development of scientific literacy for all Canadian students.

> "To achieve the vision of scientific literacy, students must increasingly become engaged in the planning, development, and evaluation of their own learning activities. In the process, they should have the opportunity to work collaboratively with other students, to initiate investigations, to communicate their findings, and to complete projects that demonstrate their learning." (p.8)

It seems that the use of a technology such as Knowledge Forum in a SFT type classroom can provide the necessary framework to make this vision a reality.

References

Brown, A. L. & Campione, J. C. (1994). Guided discovery in a community of learners. In K. McGilly (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 229-272). Cambridge, MA: MIT Press/Bradford Books.

Brown, A. L., & Palinscar, A. S. (1989). Guided, cooperative learning and individual knowledge acquisition. In L. B. Resnick (Ed.), *Knowing, learning and instruction: Essays in honor of Robert Glaser* (pp. 393-451). Hillsdale, NJ: Erlbaum.

Carey, S. (1985). Conceptual Change in childhood. Cambridge, MA: The MIT Press.

Dauite, C. & Dalton, B. (1993). Collaboration between children learning to write: Can novices be masters? *Cognition and Instruction, 10(4), 281-333.*

Jones, I. & Pellegrini, A.D. 1996. The effects of social relationships, writing, media, and microgenetic development on first-grade students' written narratives. *American Educational Resesearch Journal, 33(3), 691-718.*

Lamon, M. (1996). Schools for thought: Schooling and cognitive development. In M. Scardamalia & C. Bereiter (Chairs) Operational Thought and the Democratization of Knowledge. Symposium presented at *The Growing Mind Conference*, Geneva, Switzerland, September.

Lamon, M., Lee, E. & Scardamalia, M. (1993). Cognitive Technologies and Peer Collaboration: The Growth of Reflection. Unpublished manuscript.

Lamon, M., Secules, T., Petrosino, A., Hackett, R., Bransford, J. D. & Goldman, S. (1996). Schools for thought: Overview of the project and lessons learned from one site. In (L. Schauble & R. Glaser, Eds.) *Innovations in Learning*. Hillsdale, NJ: Erlbaum.

Lamon, M. & Ward, C. (1996). Teacher beliefs and practice in establishing learning communities. In M. Lamon (Chair) *Developing Learning Communities: Implementer Perspectives on Schools for Thought*. Symposium presented at the American Educational Research Association, New York, April.

Scardamalia, M., Bereiter, C., McLean, R.S., Swallow, J., & Woodruff, E. (1989). Computer supported intentional learning environments. *Journal of Educational Computing Research, 5*, 51-68.

Scardamalia, M. & Bereiter, C. (1996). Beyond networking: The challenge of a knowledge society. *Educational Leadership.*

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

ERIC®

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Development of Scientific Literacy: The Evolution of Ideas in a Grade Four Knowledge-Building Classroom	
Author(s): Beverly Caswell, Mary Lamon	
Corporate Source: University of Toronto	Publication Date: April 1998.

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 1	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2A	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2B
Level 1	Level 2A	Level 2B
☑	☐	☐
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here, → please

Signature: Bev Caswell	Printed Name/Position/Title: Beverly Caswell / Teacher	
Organization/Address: OISE / University of Toronto, 28 Rosedale Rd. Toronto M4W 2P8 ON CANADA	Telephone: (416) 967-7344	FAX: 978-6458
	E-Mail Address: Bev_Caswell@ dnet.oise.utoronto.ca	Date: Apr. 16/98

(over)

III. DOCUMENT AVAILABILITY INFORMATION (FROM NON-ERIC SOURCE):

If permission to reproduce is not granted to ERIC, or, if you wish ERIC to cite the availability of the document from another source, please provide the following information regarding the availability of the document. (ERIC will not announce a document unless it is publicly available, and a dependable source can be specified. Contributors should also be aware that ERIC selection criteria are significantly more stringent for documents that cannot be made available through EDRS.)

Publisher/Distributor:
Address:
Price:

IV. REFERRAL OF ERIC TO COPYRIGHT/REPRODUCTION RIGHTS HOLDER:

If the right to grant this reproduction release is held by someone other than the addressee, please provide the appropriate name and address:

Name:
Address:

V. WHERE TO SEND THIS FORM:

Send this form to the following ERIC Clearinghouse:

THE UNIVERSITY OF MARYLAND
ERIC CLEARINGHOUSE ON ASSESSMENT AND EVALUATION
1129 SHRIVER LAB, CAMPUS DRIVE
COLLEGE PARK, MD 20742-5701
Attn: Acquisitions

However, if solicited by the ERIC Facility, or if making an unsolicited contribution to ERIC, return this form (and the document being contributed) to:

ERIC Processing and Reference Facility
1100 West Street, 2nd Floor
Laurel, Maryland 20707-3598

Telephone: 301-497-4080
Toll Free: 800-799-3742
FAX: 301-953-0263
e-mail: ericfac@inet.ed.gov
WWW: http://ericfac.piccard.csc.com