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ABSTRACT

This paper describes a 4-month discourse in Computer Supported Intentional Learning Environment (CSILE) databases and the resulting classroom curriculum to identify potential factors for consideration when implementing a knowledge-building environment utilizing overlapping communities of inquiry. The study was part of a larger study of fifth and sixth graders' classroom experiences in implementing CSILE at their school. The current research involved development, teaching, and learning related to students' study of the principles of flight over 4 months. While CSILE was used in the classroom, the Web version of CSILE was used to form a discourse community in the Knowledge Society Network, which included teachers, preservice teachers, researchers, and university physics students. Researchers collected several types of data. Document analysis included reading notes in collaborative CSILE databases and reviewing students' research projects. Documents were analyzed according to science content and level of student inquiry. Researchers conducted interviews with intern and classroom teachers. Results are presented according to how parents, teachers, students, and student teachers were involved and affected. Conclusions point to future research paths in the areas of: curriculum development and teacher contact with the deep domain principles; theories of lift and the junior science curriculum for flight; connecting experts to the classroom; modes of discourse and connections to learning; better understanding of learner motivation; and clarity around the goals of classroom learning and assessment. (Contains 16 figures and 25 references.) (SM)

Factors to be Considered: Overlapping Communities of Inquiry and a Knowledge-Building Classroom

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Abstract

How does the creation of overlapping discourse communities involving elementary students, pre-service teachers, classroom teachers, researchers, and domain experts help participants to develop progressive curriculum and how is student learning impacted? And what are the factors that should be considered when shifting to a Knowledge-Building focus in an elementary classroom? The findings reported in this paper are part of a descriptive study of the experiences of a grade five/six class, their Classroom teacher and their Intern teachers as they implemented the collaborative computing system known as CSILE (Computer Supported Intentional Learning Environment). Specifically, the portion of the study reported here involves the development, teaching and learning that is related to the study of flight they engaged in over a four month period. While CSILE was used in the classroom the web version of CSILE, known as WebCSILE, was used to form a discourse community in the KSN (Knowledge Society Network) which included teachers, pre-service teachers, researchers, and University physics students. The analysis of the results presents the potential factors to be considered when implementing a Knowledge-Building classroom using overlapping communities of inquiry.The analysis section includes, (1) a case study of the Intern teacher and his shift to a more progressive concept of curriculum, (2) how the deep theoretical principles of lift discussed in the adult discourse community migrated to the student discourse community, (3) how the experts involved benefitted from their participation creating a win-win situation, and (4) how student learning was impacted by the shift to a Knowledge-Building focus and the potential factors to be considered that can influence student learning. The conclusions point to future research paths in the areas of curriculum development and teacher contact with the deep domain principles of the topic of study, theories of lift and the junior science curriculum for flight, connecting experts to the classroom, the potential importance of the modes of discourse to the progress of learning, the need for a better understanding of learner motivational issues, and the need for clarity around the goals of classroom learning and how it will be assessed.

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INTRODUCTION

Purpose of this Study

This study was part of a larger study which sought to describe participant experiences related to implementation of the collaborative computing system CSILE (Computer Supported Intentional Learning Environment) in a grade five/six class at the Laboratory School at the University of Toronto. The main purpose of the portion of the study reported here was to examine the creation of overlapping ciscourse communities involving elementary students, pre-service teachers, classroom teachers, domain experts, and interested others, all working within the same general curriculum area, and to describe how it helps participants to develop progressive curriculum and how student learning is impacted?(Morley, 1996).

Specifically, this paper describes a four month discourse in CSILE databases and the resulting classroom curriculum to identify potential factors for consideration when implementing a Knowledge-Building environment utilizing overlapping communities of inquiry.

Background

The need to prepare students for the information age is redefining what is supposed to happen in schools. Today's students will have to be able to develop their own knowledge effectively, and to participate in collaborative knowledge-building communities both in the workplace and in the wider community (Bereiter, 1995). More than two decades of cognitive science research offers approaches to learning and instruction that could help to meet these new demands (Bruer, 1993; McGilly, 1994). This research shows clearly that learning for understanding is not absorbing knowledge and teaching for understanding is not transmitting knowledge. A teacher today is still the classroom leader but, "the teacher's role shifts from standing outside the learning process and guiding it to participating actively in the learning process and leading by virtue of being a more expert learner" (Bereiter & Scardamalia, 1993, p.211). This vision of schooling as a place where teachers and students work collaboratively to understand the world is at odds with practices characteristics of most schools (Bruer, 1993).

Increasingly, researchers of educational change are implicating the lack of learning opportunities for teachers as a primary reason why reforms fail (Lieberman, 1996; Peterson, McCarthy & Elmore, 1996). Traditional forms of teacher development (e.g., one shot workshops or large group lectures) in which teachers or student teachers are passive recipients of factual information transmitted by an "expert" suggest that these modes produce little lasting change in and across classrooms (Fullan, 1991, 1993).

This is unsurprising given the mismatch between modes of learning typically provided to teachers and constructivist modes of instruction teachers are expected to implement in their classrooms.

To create substantive and sustainable improvements then, there is a great need to provide professional learning opportunities that move away from traditional in-service and pre-service modes toward long-term, continuous learning (Lieberman & McLaughlin, 1992). Recent developments in network communication may offer ways of engaging teachers in collaborative reflection on practice and development of new approaches to curriculum and its development. CSILE (Computer Supported Intentional Learning Environments) offers particular promise for developing progressive curricula and improving classroom processes because it supports cross-sector dialogue anchored in the actual CSILE work that students are producing (Smith Lea & Scardamalia, 1997). As well, because CSILE can operate on both local and wide area networks (WebCSILE), the system helps to break down barriers between sectors, a factor seen as central for reforming schools and other learning institutions (Scardamalia & Bereiter, 1993).

CSILE affords a medium bringing together teachers, pre-service teachers, researchers and domain experts in collaborative reflection on practice and development of new approaches to curriculum. But how does involvement in such a discourse help participants develop progressive curriculum and how is student learning impacted? What are the factors that can contribute to the success of such a classroom environment? To answer these questions a case study involving a Classroom teacher (RR), his Intern teacher (DH), their fifth/sixth grade students, CSILE researchers, and domain experts was conducted.

METHODOLOGY

Given that the underlying goals of this research were descriptive in nature a qualitative research methodology was selected. Because this study was intended to describe in a holistic manner the implementation of CSILE in a classroom and the complex interrelationship between the overlapping communities of inquiry it was deemed to be the most appropriate methodology. An exploratory methodology of this type also allowed for a naturalistic inquiry to take place in the classroom setting.

The purposive sample was made up of the twenty-two grade five/six students at the Laboratory School at the Institute of Child Study at the University of Toronto. The students came from middle-class backgrounds and no entrance requirements needed to be met in order to attend the school. The instructional approach of the school is progressivist in nature.

The Classroom teacher was a thirty-three years old male in his seventh year of teaching. His first six years of teaching experience had been at the grade four/five level in a local Board of Education. The Intern teacher was a twenty-six year old male who had a private pilot license. This was his first long term teaching experience. He spent four months with the class.

The subject matter concerned the principles of flight. Dialogues occurred concurrently in two CSILE databases. One database, "Look Up", ran on a local school network at the Institute of Child Study Laboratory School. The database was constructed by the Grade five/six students, the Classroom teacher and his Intern teacher over the course of the 1996-97 academic year. The database included a number of topics; here the focus was on topics concerned with flight. A second database, "The Knowledge Society Network" database used WebCSILE over the Internet. This database also consisted of a number of topics; here the focus is also on the topic of flight. The classroom teacher and the Intern teacher collaborated with educational researchers and undergraduate physics students in this database to develop anunderstanding of the physics of flight and to discuss how to teach flight. Towards the end of the semester, elementary students joined the WebCSILE database later in the term when their questions needed the attention of the University Physics Students.

Several types of data were gathered for this study. Document analysis consisted of reading the notes in the databases and reviewing the research projects completed by the elementary school children. Documents were analysed with respect to their science content and the level of the inquiry attempted by the students. In addition, several semi-structured and retrospective interviews were carried out over the course of the study. Three interviews were conducted with the Intern teacher at the beginning, middle and end of the unit. Retrospective interviews were conducted with the Classroom teacher and one of the domain experts involved in the study.

As the intent of this study was to begin to identify potential factors for further study, the analysis of the data takes a narrative form. Data is used to help explain the concepts presented in the following section with the clear understanding that this study, by virtue of its descriptive nature, has very little external validity.

FACTORS TO BE CONSIDERED: OVERLAPPING COMMUNITIES OF INQUIRY AND THE KNOWLEDGE-BUILDING CLASSROOM

The Teacher

The following section focuses on the conceptual changes that occurred for the Intern teacher as he engaged in his own personal Knowledge-Building around teaching and the physics of fllight.

Case Study: Pre-Service Teacher Development

The flight topic in the KSN consisted of 105 notes written over a four month period. The KSN discussion began about six weeks before the elementary students began their study of flight. Initially, the discussion was fairly general: interesting girls in the study of flight, possible connections between literature and flight and mathematics and flight and so on. A teacher, KF, who had taught flight previously suggested an experiment on Bernoulli's principle. This note initiated a focused discussion on the physics of flight which continued throughout the rest of the dialogue.

The first sets of notes and interpretations presented here focus on the Intern teacher, DH, interest was his changing conception of teaching and learning as he participated in a CSILE classroom and interacted in the KSN. Following each phase of notes taken both from the classroom and the WebCSILE databases, we offer a tentative analysis.

Phase I

Figure 1.1

WebCSILE Author(s): DH Note #: 189

Topic: Study of Flight

Creation Date: Jan 24, 1997 (10:15)

Builds on: Experiments and Principles

Title: Bernoulli's Principle

I have another excellent experiment to demonstrate Bernoulli's Principle. Suspend two ping pong balls from strings (at least 20 cm long) and attach the strings to a The balls should be approximately 3 cm apart. When you blow between the two balls they actually come together rather than moving apart as many students may speculate. (Bill Nye showed me this...)

Figure 1.2

WebCSILE Author(s): DH Note #: 229

Topic: Study of Flight

Creation Date: Feb. 11, 1997 (11:36)

Title: Measurement and Flight

I am considering teaching measurement through flight. There is the famous story of the airliner which ran out of fuel over northwestern Ontario because the fuel gauges in the cockpit were not functioning and the fuel needed was calculated in imperial measures rather than metric. The plane landed without incident at an old air force base. Does anybody know the title of the book (or movie) which was documenting this incident? (It's something like: Out of Fuel at 30,000 feet) This is an excellent way to show the importance of conversions in measurement.

Figure 1.3

WebCSILE Author(s): DH Note #: 230

Topic: Study of Flight

Creation Date: Feb. 11, 1997 (11:48)

Title: Teaching Flight

I've had some ideas regarding the progression of a flight unit. I was thinking of using sub-topics for the class to dissect. These sub-topics would be related to the different stages in flying an aircraft. The plane which I fly, a Cessna 172, has a checklist which includes: Walk Around, Start Check, Pre-Taxi, Taxi, Run-Up Check, . . ., After Landing, and Shutdown. Each of these stages has 10-12 steps to follow. (For example "Start Check" includes: primer locked, master on, brakes-set, yell - clear prop, etc.). Or, should I follow through with more general topics such as: taxi, take-off, cruise, landing? I think it would be really neat to follow through a progression which makes sense to flight. It would be like a ground school in our own classroom! (Top Gun!)

Analysis I

These notes and others, written by the Intern teacher early in the dialogue, suggests a view of curriculum as a list of activities prescribed by the teacher to be carried out by the students. DH's questions are oriented towards what he should do and give little sense of why these activities would be helpful for understanding flight. Notice also though that DH is interested in designing curriculum that is authentic (e.g., students would learn a pilot's procedure for flying an aircraft).

DH's responses in an interview conducted by the Classroom teacher early in the term further support the inference that DH sees curriculum as an object and that the teacher is conveyor of that object. When asked, "What is curriculum and how would you design curriculum for your classroom?", DH responded that he would begin with the children's interests but would quickly move to the curriculum documents to pick out the provincial goals and objectives he would be teaching. So his initial attitude towards curriculum development is that you begin by searching the guidelines and then design tasks and activities that would cover objectives. It is important to note that DH grants that he would not have answered in this way (on Dec. 19th) prior to the curriculum course he attended during his academic term which preceded this interview. When pushed he suggested that his view of what curriculum is, prior to the course, would have been that curriculum should start with what the kids are interested in studying. He also related in this interview his view that curriculum development is a solitary task to be completed by teachers in isolation. Even when asked about collaboration he saw no connection with curriculum development.

On the topic of the theory of flight DH stated the following in the initial interview, "The whole theory of flight, the low pressure area and the high pressure area, I sometimes get those things mixed up." At no time during this interview, did DH ever mention the study of Newton's Third Law as being related to an understanding of flight. The only connection that DH expected to occur between the classroom CSILE database and the KSN database was that he would be better able to push students to work through a question and answer format in the CSILE database. DH did expect that contact on his part with an expert in the KSN would help to improve his knowledge of flight but that it is evident that he didn't see a connection to the classroom and the student's inquiries.

Phase II

In a second set of notes and interpretations, we see how the Intern teacher becomes immersed in understanding flight for himself and brings his knowledge of flying into the dialogue (DH is a pilot).

Figure 2.1

WebCSILE Author(s): DH Note #: 223

Topic: Study of Flight

Thinking Type: New Learning

Creation Date: Feb. 6, 1997 (12:11)Builds on: force on wing, II

Title: front of wing dips down?

J, you suggest that the leading edge of the wing on an air plane actually dips down and is lower than the back of the wing. From my experience, the leading edge on wings of planes are tilted at approximately 6 degrees upwards. It is true, however, that a level wing will still produce lift. A leading edge which is lower than the back of the wing will cause the aircraft to dive.

Figure 2.2

WebCSILE Author(s): DH Note #: 252

Topic: Study of Flight

Thinking Type: My Theory

Creation Date: Feb. 27, 1997 (11:29)

Title: Bernoulli?

I have found it quite difficult to even comprehend the physics of flight, let alone teach it to the students. For me, the Bernoulli principle can explain how a level wing can generate lift based on the shape of the airfoil. My question arises when the angle of attack is increased - how can the Bernoulli principle explain lift at a 30 degree angle of attack? I believe that the higher pressure below the wing, due to the fact that more air molecules are being pushed together, is enough to push the wing up (never minding the fact that there is a lower pressure area above the wing) - - A diagram would be very very helpful at this point!!!

Any thoughts on this???

Analysis II

In this intermediate set of notes, DH introduces three new ideas. First, DH brings his own understanding into the discourse. DH is a pilot and teachers, students, and researchers had drawn upon his practical expertise at many points during classroom discussions. This is the first time that DH uses his own prior knowledge as a relevant contribution to the dialogue in the KSN. Second, DH becomes focused on the principles of flight, questions his own understanding, and offers an initial and personalized theory of flight. Finally, DH now begins to question how to facilitate students' understanding. In the last of the notes, DH mentions that a diagram would be helpful for understanding.

In the halfway interview, that just preceded his unit on flight, he notes the following, "(The) KSN has prompted me to ask questions about flight that before had appeared so clear-cut but now do not." He states that he now sees the importance of student misconceptions in guiding his classroom planning for the unit. He partly attributes this to his own experience on the KSN and the preliminary work he has done with the kids on their ideas about flight. Again, there has been no mention of Newton's Third Law in the KSN or the classroom database. The theory first appears in the KSN the day following this interview, as an explanatory note contributed by another member of the KSN to help with our understanding of Bernoulli's principle. Outside the database the first mention of Newton's Third Law comes, not at the airport field trip which is considered the benchmark lesson, but instead at a Science Outreach Program run by the local University. (See Analysis III for further details on this issue)

The curriculum documents have only been used to identify outcomes that "could" be included in a unit of study but DH doesn't see how they will make their way into the classroom. When asked directly about his initial interview idea about getting into the curriculum documents, "quickly", and whether now is the time to involve these outcomes DH offers the following, "I don't think so, not yet, we are more in a free fall with the kids around the theory of flight." He sees the current crux of the classroom curriculum as being the theory of flight, for him it is the "big hurdle". This is a big move in DH's concept of curriculum but he is still seeing the curriculum in terms of knowledge to be acquired.

The KSN dialogue has made a significant impact on DH. He is beginning to see a teacher connection that can contribute to the planning of curriculum for the classroom. In particular he states that he would like to have a curriculum expert, someone who knows the documents, engaged in KSN so he could better understand what is in these documents. This suggests that the accessibility and applicability of these documents to the classroom needs to be better examined if teachers are to be expected to make extensive use of the outcomes they contain. In addition to this curriculum issue DH also is excited about the idea that his curiosity, which used to be a private matter, is now something that he is sharing in the public forum of the KSN.

Phase III

Figure 3.1

WebCSILE Author(s): DH **Note #: 294**

Topic: Study of Flight

Thinking Type: New Learning

Title: Beatty's argument - New Theory of Flight

Creation Date: Apr. 1, 1997 (12:29

Throughout our dialogue on the physics of flight in WebCSILE, I have found both Bernoulli's Principle and Newton's Third Law incomplete conceptions. I have come up with my own theory of flight! (I have also come to the conclusion that knowledge building makes me think TOO much!!)

The early air plane wing did not have the classic airfoil shape which we see today. It was flat on both sides and yet it still flew (although not very well). Bernoulli's Principle can not explain the lift of these early wing designs. It is my belief that the early aircraft wing flew solely because of Newton's Third Law (or a push of the wing on the air below). This can be shown with a small piece of plywood (approx. 30 cm X 7 cm X 1 cm), and a moving vehicle. While driving, hold the wood out of the window with a long leading edge facing the air flow. Providing the wood is given a slight angle of attack, lift will occur! (This has absolutely nothing to do with Bernoulli).

Now, back to Bernoulli... I believe that the classic airfoil shape allows the aircraft to fly much earlier than a "flat" wing. It also allows aircraft to land at much lower speeds (a lower stall speed). Bernoulli's Principle AND Newton's Third Law work together to create lift..

The following examples have not been tested in any way - they are merely my own thoughts on lift.

- At 0 degrees angle of attack, Bernoulli's Principle accounts for 100% of lift and Newton's Third Law accounts for 0% of lift.
- At 10 degrees: Bernoulli: 70% of lift N3: 30% of lift
- At 20 degrees: Bernoulli: 50% of lift N3: 50% of lift
- At 30 degrees: Bernoulli: 40% of lift N3: 60% of lift
- it continues like this until the stall speed is reached, and the wing falls out of the sky.

What is your thought on this?

Figure 3.2

WebCSILE Author(s): DH Note #: 351

Topic: Study of Flight

Thinking Type: New Learning

Title: Theories

Creation Date: Apr. 22, 1997 (10:51)

I have found Terry's latest entry very helpful to understanding causality. Everyone has valid explanations of this "unbelievable" phenomenon called flight. I am finished my intern placement with Richard's class as of this Friday, April 25th. As a student teacher, I have found our discussion on WebCSILE useful in two ways: 1) gaining knowledge on flight for our class flight unit and 2) gaining knowledge for my own questions about flight. I shall never again fly a Cessna without thinking of our discussion. I also shall never take the phenomenon of flight for granted.

In the future when I teach flight to my own class, I will consider NOT explaining Bernoulli's Principle and Newton's Third Law to my students. If I can allow for the students to formulate their own concepts of flight in a knowledge building way - this would be ideal (I'll have to get CSILE and WebCSILE in my class!!) I have really enjoyed being a part of this discussion on flight.

Analysis III

In these final excerpts, DH offers his own theory of flight - a note that elicited many responses. As well, DH's views on curriculum have changed considerably. Rather than beginning with a list of activities and objectives, DH now sees his role as allowing students opportunities to formulate their own theories -- a process similar to his experience in the KSN. DH clearly found the cross sector discourse via the KSN useful. He and the classroom teacher did note the lack of a critical mass of teachers in the discussion. They share a suspicion that the intense physics discussion at the beginning may have made some teachers feel excluded who could have contributed to the overall unit in areas such as math and language. This lack of other teacher's perspectives on the teaching of flight was particularly disappointing to DH. How to create and facilitate cross-sector dialogue where all participants feel included and find discussions useful to their own work is an ongoing challenge.

DH did feel that how he was responded to in the KSN affected how he felt about participating in the discourse. He felt that those that were open to dialoguing and building on each other's ideas were more useful to his learning than those that seemed to be lacking for time and were abrupt and confrontational. DH wondered in the interview if the latter group had been required to participate and were therefore not necessarily there to build knowledge but instead were trying to display what they knew on the topic. There appears to be a need for research on the effects of different modes of discourse on the knowledge-building process, particularly when the interaction is between those who are considered to be novices and experts, respectively.

The deep learning that occurred around Newton's Laws was unexpected and delightful to all those involved with the class. One student, on his own time at home, went on to examine Newton's other Laws and returned to school to teach the rest of the class about his findings. This new knowledge led to an excellent discourse between members of the class about which of Newton's Laws best explained the "flight" of a baseball, first or third, or whether it should Bernoulli's Principle. What is surprising is that DH is not sure that he would have made so overt the juxtaposition of Bernoulli's principle and Newton's Third Law if it hadn't been for the field trip to Science Outreach at the University. This field trip was not selected because of its focus on the juxtaposition, but instead because of its general focus on the science of flight. The mentor teacher who had taught flight for the previous six years in a Board of Education immediately noted that he had never included Newton's Third Law in any discussion of the principles of flight. It is expected that other teachers who have had experience teaching flight could have made this insight in the KSN, if they had remained members of the dialogue. This suggests that the absence of experienced teachers in the KSN discussions was a significant problem. When setting up these cross-sector dialogues the experienced teacher component should not be overlooked.

DH indicates his new view of curriculum when he says in a KSN note, "In the future when I teach flight to my own class, I will consider NOT explaining Bernoulli's Principle and Newton's Third Law to my students." He still views the curriculum documents as important to ensure that schools are accountable to the public but he does not offer how that should take place. Perhaps a curriculum expert could be included in the database to help bring forward the connections that can be made between the children's research interests and the learning outcomes. We also see that DH has made a significant move away from curriculum as a solitary activity as he indicated in the initial interview. He now sees the importance of collaboration and the contribution the "Electric Age" can make to the develop of curriculum by groups of people. His choice of the word "people" instead of "teachers" is indicative of the value DH places on his KSN experience and its influence on his flight curriculum.

The Curriculum

The initial influence of the CSILE technology on the curriculum was on how curriculum problems were identified. Typically, the Classroom teacher would have used the Board documents to decide what curriculum was to be addressed next. Although the selection of weather and flight as topics of study was guided by past curriculum decisions he did find that particular learning issues were raised early in the use of CSILE. In particular, there was the issue of why students thought it was getting colder outside. The theories that were posted in the database indicated that several students did not have the concept of a sun-centered solar system. The Classroom teacher used this knowledge to help plan a mini-unit for later in the year.

The effect of the KSN discussion on the classroom was even more profound than the in-class CSILE discussion for guiding the classroom curriculum. It was hoped that the KSN discussion would help with all aspects of the curriculum including language and math, but the main effect was on the science of flight. The following section summarizes this effect.

The Physics of Flight: Bernoulli's Principle and Newton's Third Law

As stated, the Classroom teacher had partly chosen the unit topic of flight because he had taught it for the previous six years in his Board of Education. The topic was also deemed to be appropriate because the Intern teacher was a pilot and most of the students had displayed high interest when it was suggested at the beginning of the school year. It was expected that teacher engagement with the KSN discussion would lead to refinement of this unit of study (the Board document), including aspects of how best to characterize the phenomenon of lift and new experiments that could be done with the students.

After only a short period of time in the KSN discussion it was suggested that Newton's Third Law was another explanation for the phenomenon of lift. This suggestion was made by another teacher in the KSN database in an attempt to clarify Bernoulli's Principle. The classroom teacher immediately recognized that this idea had not been part of his flight teaching during the previous six years. He had only ever taught his students about Bernoulli's Principle as an explanation for why things fly. He had done this because the Board document that he had been following had only included Bernoulli's Principle and had made no mention of Newton's Third Law. For the Intern teacher this suggestion of an alternate explanation for the phenomenon of lift came just after a visit to a science program on flight that had included Newton's Third Law as well. Taken together, the Classroom teacher felt that this was a dilemma of understanding that was appropriate for the students to address. Notes then began to shown up in the class CSILE database with the first mention of Newton's Third Law coming in a note from the Classroom teacher. The KSN discussion then moved into a deep consideration of the physics of flight with the bulk of the notes coming from undergraduate physics students.

It is interesting to note that the newly released Ministry of Ontario curriculum has flight as the topic of study at the grade six level in the strand called Matter and Materials. However, there is no mention of Newton's Laws or the Coanda Effect. The definitions that are offered in the document, we expect for teaching purposes, are as follows, "Lift - Upward force on a forward-moving object that results when the air flow around the top of the object is faster than the air flow beneath it, and Bernoulli's Principle - A law that states that, for a fluid that is flowing steadily, its pressure is low when its velocity is high and its pressure is high when its velocity is low" (Ministry of Education, 1998). These definitions, taken along with the learning outcomes described for the flight section, appear to indicate that the Ministry's position on the explanation for lift remains solely Bernoulli's Principle. It would appear that the overlapping of the two discourse communities, CSILE and KSN, had a significant effect on the curriculum. The next section presents some of the issues brought forward by the domain experts in the KSN.

The Domain Experts

Several undergraduate physics students from the University of Waterloo were encouraged to become involved with the KSN database. One of the students was asked to try to understand the database in terms of the concepts that it contained. Their experiences are summarized in concurrently in the following section.

Case Study: University Physics Students

KH's goal was to go into the KSN discussion to create a view of the concepts it contained. She entered the database after it had been going for about two weeks. In an early interview she indicates the following, "The key thing for me from the starting point was the idea that what was really expected and necessary was to try to really get in and understand what I knew and what I didn't know. Generally I can excel at the school system but I see that as an entirely separate issue because in the school system its very rare that you actually need to conceptually understand what's going on. So, what was exciting for me was the challenge that that was what was needed to conceptually understand what was going on and to be able to explain it to people who didn't because then you really own it." KH recognizes that she is in a community where there are others trying to understand the same phenomena. However, at this point KH viewed herself as an outsider to the discussion. She stated the following, "What will be really interesting for me and what I'm looking forward to next is I want to see what comes out of what I've done to that poor database because I took the database which had a slow progressing dialogue by a number of people who were more or less connected in the same way and I walked in. Because of the circumstances I dumped an awful lot into it right away and what will be most exciting for me is to really start to feel connected to what's going on in there because at the moment I don't yet." KH implies that she is not connected to the discourse which she has become involved in but she is looking forward to becoming more connected. She also implies her feeling that the KSN discussion was in need of her help. She may actually have been correct as the set of science based notes she enters at this point sets the tone for the rest of the KSN discourse. There does appear to be some element of Vygotsky's Zone of Proximal Development in the effect KH's notes have on the teachers in the database.

Later, after one of the researchers involved in the database posted a web site for science misconceptions KH reported the following, "I read the misconceptions page and I thought, 'Oh crap, I thought that.' and from that point on I realized it was going to be more challenging than I had previously imagined. From that point on I really had to discard a lot of what I thought I would take in with me. It definitely cleared up a lot for me. I could now explain to a seven year old how lift works. I couldn't have done that before. I couldn't even have hazarded a guess. I'm pleased with that." KH seems to have developed a good sense of what it is she is getting from her interaction with the KSN database. No longer is it just that she is there to help out, but that she is now there for a personal learning need. The ultimate goal of developing a curriculum for the classroom also seems to be understood by KH.

In her final interview KH offers her theory about what happened in the KSN database, "As I said for me, one of the key things in the database was the questions that were posed. What they did was they directed my thinking far more than anything that was actually given as information and part of the way they did that is they asked things that I never would have asked." She goes on to say, "I think there's a process where you look at input by people, produced by people of different backgrounds, and because they don't have the same background as you they put it a different way, and it can trigger you into looking at the problem in a way that you never would have bothered. It just never would have come up." KH indicates there is great value in these alternate views of the same problem. In one of her KSN notes indicates how issue of trying to explain the phenomenon of lift has forced her and her physics colleagues to reconsider their theories (See the notes that follow).

Figure 4.1

Bernoulli Principle and Coanda Effect

In Fluid Dynamics at Waterloo, we discussed how air foils create lift. The explanation given was approximately as follows:

The air leaving the trailing edge of the wing **must** meet up because otherwise there would be a vacuum (and nature abhors a vacuum). The air travelling along the top of the wing has a longer path because of how the wing is shaped and so must travel faster to make up the difference. The air on the top is less dense because it is travelling faster. The pressure difference acts on the wing to push it up.

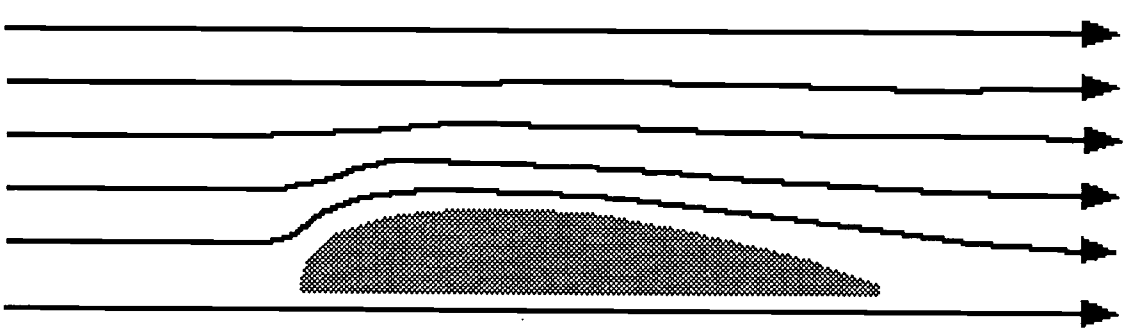
This explanation is frequently called Bernoulli's Principle.

By reading the misconceptions page (linked in the note by Marlene) and discussing it further with T S , C H , and J H I have come to understand that this explanation is:

- Incorrect
- Nothing to do with Bernoulli

The misconception is particularly nasty because it is based on incorrect facts. The incorrect theory is based on the 'fact' that if molecule A and molecule B encounter the leading edge of the wing at the same time they will both leave the trailing edge at the same time. While this is possible, it is not necessary. What is necessary for the air foil to create lift, is for the air foils shape to deflect air downwards (called the Coanda Effect).

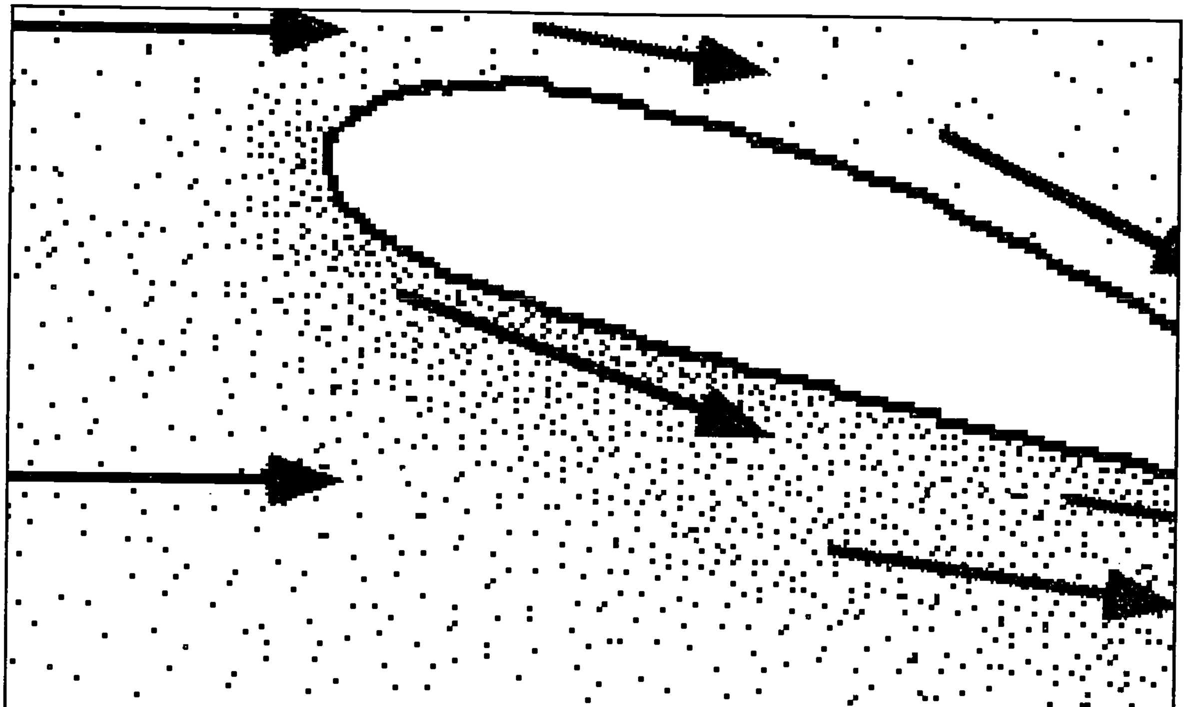
The misconception tends to ignore the effect of the wing on the air. This results in diagrams like the following:



18.

KH follows this note with an explanatory note that attempts to illustrate what is actually occurring around the wing.

Figure 4.2



I feel that the key to understanding the pressure distributions around the wing is to understanding the interactions between individual particles and the wing and the other air particles.

Essentially particles push on each other. The higher the density, the more particles push on any individual particle. When the density becomes uneven the individual pushs are no longer balanced and the particle experiences a net force.

This effect (diffusion) can be seen along the top of the wing. The air particles travel over the tip of the front of the wing. As they continue to travel horizontally they are pushed down somewhat by the higher relative air density above them. This causes the air to be bent down.

The converse applies along the bottom of the wing. The air particles are deflected down by running into the high pressure density under the wing where the horizontal streamline is blocked by the wing. The high density directs downwards particles that never touch the wing. The lift is greater as a result.

In summary, the interactions between particles and other particles causes the pressure to vary gradually away from the wing, and so generates considerable lift.

Another physics student ,TS offers a note that deals with whether or not cause and effect are problematic when we are trying to understand the principle of lift. Several more notes about causation are entered in the database. Both the Classroom teacher and the Intern teacher report that these notes helped with their overall understanding of what they were trying to do in the classroom. In the following note we see again the investment the domain experts seems to be taking in this problem of understanding when he states, " What we need is for them to have an *understanding* of flight, one that makes sense to them, and one that they can build on later in life to form deeper understanding (if they so wish)". The use of "we" seems to indicate that he sees this curriculum problem as one he too is involved in and not just as a content expert. He has a clear idea how this knowledge could benefit the students. He also relates his annoyance with never being given this other explanation sooner himself.

Figure 4.3

Author(s):TS **Note #**: 355
Topic: Study of Flight
Thinking Type: My Theory
Creation Date: Apr 25, 1997 (17:47)
Builds on: N3, causality, etc.

Explanations

First off, I apologize for my "heavy-handed rant". It was just the way things came out. Anyway, I'm sorry it came out that way.

I think part of the issue is that we have to remember what we're trying to teach kids. We don't expect them to be able to calculate exact values for lift. What we need if for them to have an *understanding* of flight; one that makes intuitive sense to them, and one that they can build on later in life to form a deeper understanding (if they so wish). That was the main point of my "rant".

I don't want kids saying "oh, this happens because this law says so". I want them to say "oh, this happens, and it makes sense, and this law here is a neat way of codifying that". I really like D 's idea of not teaching them any specific reason for flight to start with, and letting them figure out possibilities for themselves.

What I really like is that flight really is simple. Anyone can understand the "air hitting a tilted wing pushes the wing up" idea. It makes intuitive sense. I regret that I was never given that argument while I was growing up. When I finally had it told to me in that form (*AFTER* I'd taken a university course in Fluids, which is supposed to teach you about flight), I had one of those "Aha!" moments and everything clicked into place. It's that moment of "Oh, wow, the universe makes sense!" that I really like to see in people. It's what attracts me to teaching.

The Parents

An information night was held early in the school to communicate to the parents the nature of Knowledge-Building classroom and how CSILE was going to be used. There was general support for the processes involved, the greatest support coming for the idea that the students would be getting an opportunity to use computers on a regular basis. It remains unclear what the parent's understanding was about the nature of a Knowledge-Building classroom. The attitudes and expectations of the parents seemed to range a great deal. However, one parent anecdote is particularly interesting.

The Issue of Parental Expectations

T's dad is a good example of an individual who in our society could be very nervous about this new approach Knowledge-Building represents. T chose, after a lot of preliminary researching time, to focus his attention on the deep conceptual issue of what is happening at the surface level of the wing with respect to fast moving fluids and low pressure. He could be seen to be following this inquiry on many occasions with the various contraptions (Bernoulli rings, paper planes, etc...) that he made and brought to class. However, when it came time to share his progress with the class he could only offer that he had tried to learn about this problem through numerous little experiments. For the Classroom teacher the success was that T had stayed with that line of inquiry and had not moved away from it in favour of other questions which were more easily answerable (see the Bristolboard Effect in the Artifacts section p.28). On the report card, as well as during class, the Classroom teacher had made the following comment, "T has done excellent work related to our class inquiries around flight. To his credit, T can remain involved in exceptionally difficult inquiry questions that other students would normally abandon in favour of easier ones. In particular, his work with the Computer Supported Intentional Learning Environment (CSILE) was outstanding. Our class has really benefited from T's ability to ask difficult questions." Ts father took the time after the report had gone home to send the Classroom teacher a note in the mail about his appreciation for these observations. The note went as follows,

> Thank you for listening and noticing that T is looking for a fundamental answer in the Bernoulli question. The enclosed article is from "Genius' by James Gleick. (the part of the article that he highlights is as follows) "By the time Carl (his son) was four, Feynman was actively lobbying against a first-grade science book proposed for California schools. It began with pictures of a mechanical wind-up dog, a real dog, and a motorcycle, and for each the same question: What makes it move? the proposed answer- Energy makes it move" - enraged him. That was tautology, he argued - empty definition. Feynman, having made a career of understanding the deep abstractions of energy"

The Students

The CSILE claim is that, "CSILE has the affordances for altering school discourse patterns in ways that lead to self-directed, sustained, intentional knowledge advancement, with knowledge advancement viewed in a social - not purely individual context" (Scardamalia, 1996). For the Classroom teacher the initial issue around student learning was a needed shift in his concept of what self-directed learning entailed. The Classroom teacher had used the Inquiry Process extensively in his old Board of Education. The Inquiry Process was a very structured process and required a product to be produced at the end of the inquiry. Problems encountered during the initial unit of the year had indicated that the process had serious conflicts with the functioning of a Knowledge-Building classroom. Thus, the process was not used during the flight unit. However, the question forming portion of the Inquiry Process was used to judge the depth of student inquiries, as being either deep or shallow.

The experiences related to student questioning indicated that some students would stick with deep principled questions because they were focused on the deep concepts while others would surface for various reasons. These reasons seemed to include: motivation around their topic, resources (availability/ complexity of ideas and reading level), final presentation format, and a related matter of fear of failure if they were not successful in their inquires. Associated with not being successful in their inquiry was the issue of student's ideas of what successful "Knowledge-Building" really look like.

This section, the student factors to be considered, is organized around the following topics: the type of learning engaged in by the students, "Intentional Learning"; the use of reference materials in the classroom, "Resources and the Knowledge-Building Classroom"; the nature of the products developed by the students and how they may contribute to student learning, "The Artifacts of Learning"; and student assessments of Knowledge-Building in the database, "Student Assessments of Learning".

Intentional Learning

Intentional learning is at the core of what is desired in a Knowledge-Building classroom. Scardamalia and Bereiter have described an expert learner as one who continually reinvests their mental resources in addressing the problems of ever increasing complexity (Scardamalia, 1993). Throughout the year the Classroom teacher attempted to encourage students to seek out inquiry questions that were at the edge of their competence. It did appear that interest had a great deal to do with how long and how deeply students would stick with different questions. Those questions that were of importance to more than one member of the class seemed to be particularly motivating. This raises the idea that motivation is socially co-constructed and may not be a stable trait (Pedraza, 1996). The data and theory in this area are still being reviewed but the following two examples can be shared at this point.

The first example of intentional learning is the case where the class was solving the Jasper Woodbury problem "Rescue at Boone's Meadow". The goal of this contextual math problem is to determine the quickest route to rescue a wounded eagle. One of the groups started to wonder about whether the ultralight plane would speed up as it burned off its fuel. This led to a discussion between several students about whether the burning of fuel affects lift or whether it affects forward speed. As this question seemed to be outside the resources of the classroom teachers the students were encouraged to bring their question to the KSN database. The following set of notes summarizes the discourse.

Figure 5.1

Author(s): DH **Note #:** 309
Topic: Study of Flight
Thinking Type: No Thinking Type
Creation Date: Apr 4, 1997 (10:59)

Jasper questions

The following two students have an issue around some basic principles of flight. This "argument" has developed during our solving of the Jasper problem "Rescue at Boone's Meadow". We are hoping someone can help us with this issue.

A

I think that if there is less weight on the plane then the maximum weight the plane will go just a little bit faster. (For examle, if the maximum weight is 210, and the pilot is 120 and the total weight for the fuel is 30 the plane will go a little bit faster because there is less weight on the plane then the maximum weight.) Now, I am not saying that it would go a lot faster, just a little bit. Because, for example if you are pulling two children in one of those small wagons, then one child gets out it is easier to pull just the one child, so the small wagon goes just a little bit faster. When there is less weight, it is easier to pull/fly, so you go a little bit faster. I am probaly not explaining this right, but I hope you understand what I am trying to say. If there is less weight on the plane then the maximum weight the plane would go a little bit faster.

Z

I think that if there is less weight on the plane then there would be the same amount of lift, but that amount of lift would lift the plane higher. The four forces of flight are lift, going up, weight, going down, thrust, going forward, and drag, going backward. Drag and thrust are opposite forces. If there was more drag, then the same amount of thrust would not push the plane as fast. If there was less drag, the plane would be able to go faster on the same amount of thrust. The same thing would happen with weight and lift, if there was more weight, the same amount of lift would do less. If there was less weight the plane would be able to fly higher with the same amount of lift. It would not affect how much the same amount of thrust would push the plane.

Figure 5.2

Author(s): Richard
Note #: 315
Topic: Study of Flight
Thinking Type: No Thinking Type
Creation Date: Apr 7, 1997 (14:01)

Jasper - another voice

In putting the last question on the KSN it stimulated discussion within our classroom around this topic of weight/lift/drag. I asked one of the people involved to enter what seems to be another point of view on this topic.

T
It wwill fly faster because the motion foreward depends on the amount of thrust, weight and drag(which doesn't change). If Richard :-) is pushing as hard as he can on a 200 ton basketball it will go slowern than if he pushes as hard as he can on a 1 ball. The motion up depends on the motion foreward, the load and the shape of the wing(which doesn't change) and because the speed is faster and the load is lighter it will also go higher.(I'm tired)

Figure 5.3

Author(s): H
Note #: 330
Topic: Study of Flight
Thinking Type: My Theory
Creation Date: Apr 14, 1997 (8:51)
Builds on: Jasper questions

Less Weight...A

Comment on A Note

If you were going to run out of fuel in the Jasper Problem (Rescue at Boones Meadow) wouldn't t begin to get more lift because the force of weight (the force pushing down) would be less, allowing the lift (the force pushing up) to take advantage of it. The aircraft would begin to get more lift than it had had before, and it wouldn't really get any more thrust, only more lift.

Figure 5.4

Author(s): KH **Note #:** 336
Topic: Study of Flight
Thinking Type: New Learning
Creation Date: Apr 16, 1997 (10:38)
Builds on: Less Weight.

RE: Less weight

Hi H

I agree with your comment about A 's note. The amount of thrust will not change because gravity is less. But we also know that the same amount of push can have a larger effect on a lighter object. (Imagine throwing a bowling ball and a rubber ball the same size.) So while the amount of thrust stays the same, the total force on the plane will have more effect.

The math that goes with this is like this:

Total Force on an object = mass x (rate of change of the object's velocity)

Let's consider just the changes in the horizontal direction... then:

(Thrust - Drag) = Mass x (rate of change of horizontal velocity)

We know that thrust and drag aren't changed by the plane's mass (they depend on the plane's shape and velocity, right?) So if the plane loses weight til it's have it's original weight, the plane will speed up twice as fast as before it lost the weight!

But wait a minute, what happens when Thrust equals Drag. Well, balanced forces mean that their is no total force acting on the object. This means that the object is not speeding up or slowing down. When the weight is halved, it still has the ability to speed up twice as fast. But, twice as fast as zero is still zero, so the plane will continue at a constant horizontal velocity.

It is interesting to notice that the students seem to be reasoning freely with the concept of forces and how they can be used to explain flight. Some students were a bit turned off by what they felt was a high level response from KH the physics student. Regardless, this question was highly engaging and required substantial investment from the students involved.

The second example of intentional learning was the inquiry question that two students developed out of a magazine article about why so many home runs are hit out of Coors Field in Denver. The following notes summarize this discussion. The first note (Figure 5.5) is the disucssion note from the classroom CSILE database.

Figure 5.5

P:Coors Field? Ball Carries

Theory Building | Air Pressure

P: The Colorado Rockies play baseball at Coors Field in Denver at an altitude of 5,270 feet above sea level. Why does the ball carry an extra 50-70 feet as compared to other ballparks that play at sea level?

[1] MT: Since there are less air molecules obsuring the ball, it will carry more than in other places. (SM)

[2] MT: I think that the ball goes faster because there is less air stopping the ball - Newton's Third Law! (SJB)

[3] C: How could this idea be compared to aircraft flight? (What are the flight characteristics of a plane at 100 feet auuve sea level versus the characteristics of a plane at 6000 feet above sea level? (DH)

[4] MT: m and I, think that the air is thinner at 5280 feet (Coors Field) than at sea level. The air density at coors Field is 1.071, and at sea level it is 1.225. (SM)

[5] NI: What S and I have read is that Newton's First Law says that every object remains at rest or in a straight line. Motion at constant speed unless it is made to change because of an outside force (a push or pull).
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[6] NI: The numbers you have included are very interesting. Can you tell us where you got the numbers from and what the units are that they are describing the air in?
(RR)

[7] C: Sorry R we forgot to say the units but it is mesured in kg/m3. (SJB)

new | Add | Refresh | View | ?

●: Do balls "fly" or "glide"? (RR)

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26.

Figure 5.6

Author(s): Z
Topic: Study of Flight
Thinking Type: Problem
Creation Date: May 29, 1997 (9:24)

Note #: 416

First or Third

Recently, S and S did a presentation on why the baseball goes farther in Coors Field in Denver, Col. than in any other ballpark. The general consensus seemed to be that it goes farther because there is less air pressure. While S & S said this was Newton's first law, I think it would be Newton's third law because in lower air there would be fewer air molecules to create resistance to the ball, hence it goes farther. Can anyone help us?

The debate that student Z refers to occurred during what was to be a "sharing time" for the Coors Field group. The issue of understanding Newton's First Law vs his Third Law was brought to the class not by the teacher but by one of the students who had gone to the library to get a book. The part that was most interesting was that t the debate that surfaced seemed to get stuck and really needed someone to move it forward. Student Z made a plea at the end of his note for help from the physics students but by that point in the school year all of the University students had left for the summer. This was not a topic they could find in the reference materials on hand so the issue remained unexplained for some time. This raises the issue of resources and their importance to a Knowledge-Building classroom.

Resources and the Knowledge-Building Classroom

The value of suitable resource materials to the Knowledge-Building classroom should not be underestimated. During the first unit on weather there was a lack of suitable resources that addressed in any depth the specific research areas of the students. General texts were the only type made available in the classroom. This resulted in a great deal of opinion giving and very little in the way of Knowledge-Building that could be found in the database. In addition, it was clear during the unit that specific characteristics of the reference materials had affected how students had proceeded with their inquiries. The features identified were: (1) reading level of the material, (2) conceptual complexity of the material, and (3) availability of resources. With respect to reading level and complexity of the material it has been noted that several techniques for the reading of more difficult texts should have been employed. One such technique is Reciprocal Teaching which is employed in classrooms organized around Fostering a

Community of Learners (Brown, 1994). This technique would have enabled groups of students to read more advanced material by having students aiding each other's reading of the content. On the issue of availability of appropriate resources it has been apparent that an adult member of the class needs to be dedicated to the pursuit of finding suitable reference material as well as the students. During the flight unit a University student was hired to support the research in this classroom and resource gathering was part of the job she was given. This approach to the gathering of reference materials removes the student somewhat from initially locating the texts, but the students would still remain the one's who need to overtly make specific requests for reference materials. The issue of conceptual complexity and reading level of the material came out on several occasions where students had changed their questions because they had found the texts they were able to locate were too difficult to understand. So it would appear that the matching of the reference materials to the student's levels, both conceptual level and reading level, is a sensitive yet containable factor in a Knowledge-Building classroom.

Another factor that related to the changing of research questions was the artifacts created and how student learning was to be assessed.

The Artifacts and Sharing of Learning

As stated, the goal of the flight unit was the pursuit of deeply principled questions. Many students chose questions that related to the physics of flight but others chose topics and questions that dealt with things like migration and air plane engines. Students were required to keep notes about their inquiries and sharing times were established for each group. In reviewing the nature of the artifacts that the students chose to produce for their inquiries there is one theme that is observable. The students who had begun their flight research with deeply principle based questions but then switched to more surface level questions had a tendency to exhibit a behaviour we are calling, "The Bristolboard Effect".

When asked, during the sharing of their knowledge advancements, about why they had changed their questions three of the students suggested that they had not found enough material on the other question. Two of the three made the direct statement that, "I couldn't find enough information to fill up my bristolboard." Further, many student had photocopied pages from books pasted on their bristolboard. This issue again raises the problem of resources but we also feel that in this behaviour there is an element of just getting a task completed. We are just beginning to look at this behaviour of "surfacing" on a deep question and the idea of filling up bristolboard from the standpoint of Carol Dweck's work on Mastery Learning vs Performance Learning (Dweck, 1988) Dweck has proposed that the student's who have a fixed view of intelligence are more likely to be focused on performance while those that view intelligence as malleable are more likely to be focused on their learning of the topic in a mastery way (Cain, 1995). For us this would translate into the task oriented fixed student potentially being those who changed their questions and the mastery oriented students being the ones that were able to stick with the deeper more difficult questions. Unfortunately, data was not gathered about the student's theory of intelligence so this research has been proposed for future research.

What can be pointed out here is that even though the teacher went out of his way to avoid suggesting bristolboard or even using the word project to describe what was going to be happening during the "sharing times" the students inserted these ideas on their own. It appears that this project focus is very ingrained in many students. It has been suggested that perhaps it is the fear of failure around the presentation since it is seen by the task oriented students as a time to "display" their intelligence. The Classroom teacher did attempt to be very explicit that the "sharing time" was to be about sharing the current state of their inquiries and that the students would be more responsible for their own assessments of their learning, but this didn't seem to help. The nature of assessment and its effect on learner choices related to inquiry questions and the artifacts generated is another area then that should be researched in a more rigorous manner.

Student Assessments of Learning

The area of assessment that was examined during this study was student assessment of Knowledge-Building (KB) in the database. At the end of major periods of study the discussion notes from the database were printed out and "Database Analysis Sheets" were used by groups of students to assess whether learning and knowledge-building had occurred in the database. How this instrument was developed and used is summarized in the following section.

After the first unit about weather (which ran from mid-November to mid-January) it was apparent that the class as a whole was not totally cognizant of what it was to be doing Knowledge-Building. There were several good examples of KB in the database but we weren't sure that even those who were engaging in KB were aware of what they were doing. There was a lot of unsupported opinion and reference-less arguing going on in the database. It seemed to be one thing to talk with the class about KB but quite another to have them actually be doing KB in the database.

As this was the first attempt at using CSILE and KB in this classroom setting we were very concerned about the quality of the database as an object unto itself. It was expected that we would share our work with the parents through an evening presentation followed by student sharing of the database to that point. Part of the thinking in preparing the Database Analysis Sheet was that the students needed to be able to identify which questions still remained unanswered despite having been dealt with in the database.

At this point in the year the Classroom teacher was also beginning to feel that some students, and the Classroom teacher included, were having trouble "seeing" what was happening in the database. So we just wanted to print the database so we could see, physically, all that was going on in the database.

In summary then, the goals for the use of this assessment instrument were as follows: (1) To identify instances of "good" KB and to be able to talk with the class about these examples, (2) To probe the database to identify future directs and questions for the class to follow, and (3) To help the students to be better able to speak to their parents about the whole of what was going on in our database and be able to share all of the database not just the area they had been focusing their attention over the past month and half. The results of these Analysis Sheets indicated that many student groups were able to identify where learning had occurred but that these groups reported relatively little Knowledge-Building happening to accompany these advances. The choice of groups as opposed to individuals and the lack of a baseline around student concepts of KB are significant errors in the methodology which makes it impossible to identify what KB is for individual students. Better data on student's conceptions of KB needs to be gathered so that individual changes can be understood.

IMPLICATIONS FOR FURTHER RESEARCH

The suggestions that follow are the opinions of the author based on the data contained in this study. As stated earlier, the external validity of these findings is weak given the methodology that was utilized. These suggestions for further research will require an alternate methodology to increase their validity.

Curriculum Development and Teacher Contact with the Deep Domain Principles

The data presented in this paper seems to indicate that we need to connect teachers more directly to the larger pool of ideas out in the world as opposed to having those ideas interpreted through curriculum documents that don't reflect the current understandings or dilemmas in the domain of study. Further research involving the overlapping of discourse communities that include elementary classrooms and University students seems to be a fruitful direction for further research.

Theories of Lift and the Junior Science Curriculum

According to the curriculum documents the only possible explanation for why things fly would seem to be Bernoulli's Principle. This is evidenced by the omission of Newton's Third Law and the Coanda Effect from the curriculum documents on flight from both a Board of Education and from the Ontario Ministry of Education's 1998 curriculum (Ministry of Education and Training, 1998; Halton Board of Education, 1990). However, the results described here would seem to indicate that at least Newton's Third Law is conceptually understandable to students at the grade five/six level. It would also seem that having multiple theories to reason with around a phenomenon, such as lift, is a better way to approach science if the classroom intention is to push for student theory building. More research is needed to establish if these alternate explanations for lift are developmentally appropriate for grade five/six level students.

Expert Connections to the Classroom

It appears that a good Knowledge-Building classroom needs to be a connected classroom. It needs not only to have its members connected to each other but it also needs to be connected to the real world of ideas and the people who embody those ideas. The other side of these external connections is the experience of the "experts" who are connecting to the classroom. What seems most interesting and worthy of further research is how the best interactions occur because the experts themselves are interested in exploring the questions that have been raised. This is not the "ask the expert" model that has been used before, but this is instead an "engage the expert" model that levels the playing field for the teacher and for the children. How to create these learning situations that don't deteriorate into knowledge telling by the experts is an important area of research around the overlapping of communities of inquiry.

In addition, there are some problems with expert involvement that are also worthy of further research. One issue is how experts level or scaffold their ideas for the students who engage them directly. Several experts during these units had a tendency to either dump too much information on students, or they didn't go deep enough because they may have assumed the students weren't capable of understanding the content. If experts are going to be more directly connected with the classroom we will need a better understanding of how these interactions can be properly mediated so learners are being met at their level of understanding. This may require separate discussion spaces for teachers/experts and teachers/students until students have the need to access the ideas contained in the other discourse community and then have direct contact with the experts.

Modes of Discourse and Learning

One area that may help with expert/student interaction as well as student/student interaction is a better understanding of the types of discourse that fosters Knowledge-Building and those that do not foster KB. The data presented here suggests that many of the children, when they were without resource materials to work from, engaged in debates that were devoid of KB and learning. In the KSN the Intern teacher suggested that he felt that those experts that were open to dialoguing and building on each other's ideas were more useful to his learning than those that seemed to be lacking for time and were abrupt and confrontational. It is suggested that an examination of the role of dialogue in the Knowledge-Building process be pursued. The study of dialogue seems to be progressing in business with respect to how teams function but it is also needed in these classroom situations (Senge, 1990; Bohm, 1996).

Intentional Learning and the Goals of Classroom Learning

The data from this study around the artifacts and assessment of learning seems to indicate that more research is needed around student awareness of the goals of their learning and how learning is going to be assessed. If the goal of a Knowledge-Building classroom is to have intentional learning about questions related to deep domain principles then a better understanding is needed of how to make this work for all of the students in the classroom. There seem to be fruitful paths for research around student theories of intelligence and the notion that motivation is co-created based on the learning topic.

But on a larger scale the goals we have for the education and for our children seems to be an even larger area in need of study. In particular, it is the attitudes and aspirations of society and the parents in particular that seem to be of particular importance to try and understand. In this study the parent who thanked the teacher for noticing their child had been trying to learn Bernoulli's Principle in a deep way, and not just trying to memorize the definition, represents the parent that is needed. On the other side of it though there appears to be a vast expanse of people who see education as a means to an end, or as it was put in "The Manufactured Crisis" as the means to a job, and then to a better job and so on (Berliner, 1995). What is needed for Knowledge-Building classrooms to flourish and for overlapping discourse communities to be successful is for the focus to be on learning for learning's sake. It is as John Dewey liked to say, "the aim of education is growth, and when he was asked growth toward what, he liked to reply, growth toward more growth. That was his way of saying that education is subordinate to no end beyond itself" (Cremin, 1990). In many ways it would seem that a lot about how people view education will need to change before Knowledge-Building and learning for learning's sake becomes the focus of the classroom.

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