The Social Context Surrounding Learning with Visualization Tools

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Introduction

As others have documented, creating a productive social context surrounding learning with sophisticated visualization and modeling tools is a highly complicated endeavor with few roadmaps or concrete suggestions to guide teachers' efforts (i.e. Spitulnik, Krajcik and Soloway, 1999; Roschelle and Pea, 1999; Lee and Songer, 2000). Many teachers conscientiously work to capitalize on both new tools and inquiry-focused pedagogy to help their students grapple with real-world data, modeling scientific phenomena and formulating their own queries about such events as real-time, Internet-available hurricanes brewing in the Atlantic. Despite the potential for productive higher-order thinking with these tools, many teachers also recognize that potentials are often not realized, in part, as a result of an incomplete understanding of how to orchestrate a social context that supports students' higher-order thinking, collaboration and critique. This paper outlines some of the lessons learned from our research group, *One Sky, Many Voices,* relative to the use of a suite of technological and non-technological resources towards the creation of a productive social context focusing on middle school students' study and forecasts of current weather events.

Research-Based Lessons Learned

We designed our own Internet browser and middle-school focused interface for students' simple and efficient observation of current weather events such as fronts in North America and hurricanes off the East Coast of the U.S (Samson et al, 1999). To support productive dialogue around these visualization tools and across 200 classrooms distributed throughout North America, we employed an Internet-based threaded-discussion board of our own design (see Lee and Songer, 2000) for the organized discussion and interpretation of current weather events. Participants included about 1500 middle school students, scientists, and teachers on each of ten discussion boards. All students, scientists and teachers were following the same eight-week, inquiry-focused weather program called *Kids as Global Scientist: Weather* (Songer, 1998).

In our efforts over the past several years to support a productive social context we discovered many things including both some beneficial observations and some less so. Three of these are presented and discussed below.

Observation 1. Students were more active in Message Board discussions than in traditional classroom conversations.

In traditional classrooms most whole-class discourse is led and dominated by a teacher or a small number of students. According to Bellack (1966) teachers initiate most classroom talk and in Mehan (1979) 81.1% of total discourse was teacher initiated. In contrast, on our Message Board students initiated a majority (82.8%) of the total messages including 91.1 % of the original messages containing questions and 91% of the responses to other students' queries (see Lee and Songer, 2000).

Caveat Related to Observation 1: Threaded –discussion boards are good for multiple voices but often bad for quick decision-making.

Our research suggests that threaded Message Boards like ours are potentially useful in situations where it is important to represent multiple voices on a particular topic, particularly if the topic benefits from multiple interactions from one or multiple initiations. In contrast our research and that of others (see for example Hewitt, 1997) suggests that these Message Boards are not a good medium for quick consensus or efficient decision-making. Because of the sequential organization of message threads it was often difficult for our users to reach consensus on a given topic or to converge on one idea. Research by Jim Hewitt (1997) on webCSILE also suggests that the hierarchical structure of threaded discussions discourage the convergence of ideas.

Recommendation Relative to Observation #1

We recommend that programs utilizing threaded message boards, as currently configured, take into account the benefit of many individuals actively representing multiple views and the weakness of reaching consensus easily . A good role for current electronic message boards within classrooms might be as a precursor or complimentary means to a traditional whole classroom conversations, particularly in instances where it is important for all learners' voices to be heard.

In addition we recommend the design of new threaded Message Board systems that provide different forums or structures, i.e. not hierarchical, for conversations where consensus or quick decision-making is important.

Observation # 2. Scaffolding by scientists on the Message Board provided learning opportunities that could be customized to individual or small group learners' needs.

On our Message Boards scientists provided three different types of customized information to guide students' scientific inquiry. All three of these types of information represent material that was essential to our students' knowledge building but not commonly present in traditional middle school resources even when students use the Internet. First our scientists provided regional customization for students—i.e. explanations of local events such as regional floods or the interaction of local geography to weather events. Students found this dialogue not only specifically tied to their individual queries but a rich context for learning traditional science concepts such as the water cycle:

> *Posted by SFE School, TX on March 06*
> Dear Weather Specialist, In the north we have been experiencing heavy rain. The Ohio River is flooding and major rivers are flooding down here. We have had rain all week but the weather has finally changed! It is cold and windy. Should we expect more rain because of the rivers?
>
> > *Posted by **Weather Specialist**, on March 10*
> > Glad to hear you are finally starting to dry out! As for getting more rain because of the rivers, I had always thought that if it rains here in Delaware, the water must have come from a nearby lake. But, as it turns out, most of the rain you get probably started out far away from you, possibly even as ocean water. One way to look at it is to look at a map of the U.S. Notice how small the Ohio River looks at that scale, then remember how big an area it was raining over. Anyway, hope you don't get that much rain again for a while!

Similarly, scientists provided temporal customization to students relative to scientific concepts such as El Niño, a concept very popular in students' queries but not well explained through other traditional school resources.

> *Posted by T School on October 09.*
> Q1: Do you think El Niño is really keeping hurricanes from forming in the Gulf of Mexico this fall? Q2: What makes El Nino reverse the direction of the flow of warm water across the Pacific? Q3: Does El Nino mean we may get more snow in Fort Worth this winter? We hope so! :-)
>
> > *Posted by Hurricane Specialist on October 10.*

> A1: Definitely! Aug and Sep were the least active peak months of hurricane season since 1944.

Third, at times scientists provided information to students that challenged them to learn more, rather than providing them with specific or overly simplistic answers. We call this kind of interaction pedagogical customization, where the scientists' response is customized to the students' question leading to a more in-depth examination of the concept or idea. For more examples and discussion of these ideas see Lee and Songer (2000).

Caveat Related to Observation #2: Explicit Modeling of Appropriate Responses for All Experts is Required.

While in our study several different types of customization of scientific content were observed, such customization is often difficult to orchestrate for many reasons including a) an inability of some experts to provide an appropriate level of content help; b) an inability of some experts to provide appropriate scaffolding (i.e. provide only direct answers rather than guiding students towards an answer), and c) an inability of teachers to promote equitable information to all students**.** Our research suggests that it is important for classroom teachers and others to monitor such interactions carefully to ensure productive conversations. In addition, whenever possible, specific guidance of experts is essential to maximize the possibility of beneficial conversations. A good guide with suggestions on how to support productive mentors is now available (Collison, Elbaum, Haavind, and Tinker 2000).

Recommendations Relative to Observation #2
Use Message Boards for modeling and mentoring that compliments opportunities for guiding individual queries realized by the classroom teacher.

As more instructional programs explore means of helping a range of students to have greater opportunities and ownership for their own learning, additional resources are needed to provide guidance and support for students in the understanding and monitoring of their own learning processes. At times, Message Board correspondence served as a very supportive complimentary resource for teachers in our program. On balance, we recommend such dialogue only as a means to compliment traditional classroom activities and mentoring and never as a replacement for good classroom practices.

<u>Observation #3 Social dialogue fostered on-going collaborations and provided a strong and meaningful context for learning science through four different types of social-scientific dialogue.</u>

In our program students introduce themselves and then later in the eight-week program use each other as resources to study weather patterns through the experiences and expertise of other students. We found that early socialization was a key factor in sustained collaboration. The large diversity among KGS participants provided a larger range of scientific resources, including personal experiences, than typically available in one homogenous classroom. In our program four different types of social-scientific dialogue contributed to students' ability to question, explain, and determine the difference between evidence and observation—all important components of scientific inquiry.

First, the variety of students' personal experiences with weather led to productive expansion of students' thinking about weather variations. In the Data Comparison activity students in Indiana noticed that our site in Guam was the only school with a high temperature of 80 °F in March and inquired about cold weather in Guam. This query led to a productive exchange of both personal and scientific data that added richness to these students' understanding of weather:

> *Posted by S Elementary School, IN on March 11*
> HI! We just finished mapping out your temperature, for those 2 weeks in February, that you sent in weather data. While I was doing that I noticed that you were the only school with temperatures in the 80's. Almost all the other schools were in the 30's, including us. <u>What is the coldest it has ever been at your school?</u>
>
> > *Posted by MB School, Guam on March 11*
> > Hello, so you mapped our temperature. What do you think about the temperatures we're having? We're close to the equator; that is why we have the temperatures in the 80s all year around. <u>The coldest temperature we have is somewhere in the 60s.</u> Like to hear from you again, Don.
> >
> > > *Posted by S Elementary School, IN on March 12*

> Hello, we think your weather is pretty neat. Over the winter, it got to be -15, a few times [in our area]. I think you guys in Guam would really like snow. <u>Do you have tornadoes where you live?</u>
>
> > *Posted by MB School, Guam on March 12*
> > Hello, well if you live here for all your life you would not like the weather here. You asked if we get tornadoes here, well we don't because the island we live on is only 32 miles long but we do get waterspouts. <u>Do you know what a waterspout is?</u>

Second, severe weather events experienced by project members provided an unique learning opportunity to understand both the scientific and human dimensions of the science of weather. During this program severe flash floods occurred in the Houston, Texas area. After students in Houston posted a message regarding their flood other participants responded with concern for these students and their situation. These severe weather events such as hurricanes, tornadoes, and floods also provide excellent contexts for the ability of students to think critically to make the relationships between evidence and explanations come alive, as outlined in the National Science Standards (National Research Council, 1996, p. 145).

Third, at times participants responded to others' challenge questions towards a "reciprocal toss" (van Zee and Minstrell, 1997) kind of dialogue where each response "tosses" back another challenge to the learner, as opposed to a teacher's evaluation of a response as often happens in traditional classroom dialogue (see Lee and Songer, 2000). In the example below, a scientist responded to a student's invitation to discuss his favorite cloud, which, in turn, led to a rich dialogue of the common patterns between cloud types and weather patterns.

> *Posted by GV School, NH on January 29*
> <u>What's your favorite cloud?</u>
>
> > *Posted by Weather* ***Specialist****, on January 29*
> > My favorite cloud is the cumulonimbus. <u>Do you know what type of weather is associated with a cumulonimbus cloud?</u> If you do you might be able to figure out what one of my hobbies is. Let me know: 1) what weather is usually found with a cumulonimbus, 2) take a guess at what hobby would be related.
> >
> > *Posted by GV School, NH on February 06*

> Cumulonimbus clouds are associated with high wind speed and thunderstorms. We were guessing that it would be hang gliding or ballooning. We were wondering if you do any of these sports?
>
> > *Posted by Weather **Specialist**, on February 07*
> > Hello Cumulus kids. You sure know your clouds! I have never hang-glided or went ballooning, but I am a private pilot (but that isn't the hobby I am talking about:). Cumulonimbus clouds are usually associated with bad weather, so I don't think to many people would want to hang glide or balloon near them. I'll give you another clue about the hobby I am talking about: Have you ever seen the movie Twister??

Fourth, our program cumulates with real-time prediction activities. All students forecast a given city each day for a week. Students living in that region serve as "local experts" on what actually happened in their city on that day. Other students pose questions to these students leading to a rich and personal dialogue full of both personal and scientific information:

> *Posted by S Elementary School, IN on March 04*
> Dear H School [in New York], We are the precipitation group at S Elementary. We have just looked at [the One Sky Program real-time weather maps] and we have predicted that today, Tuesday, March 4, your weather will be cold with light snow. Please let us know if we were right or wrong.
>
> > *Posted by H School, NY on March 12*
> > Hi. You were about right in your prediction... it was a bit colder Tuesday than it had been and we had a little bit of snow before school. I wrote this to you before but we were disconnected as it was being sent in
> >
> > > *Posted by S Elementary School, IN. on March 13*
> > > Hi. We received your letter, we're are glad to here from you. We've gotten pretty good at predicting the weather. We think you will have rain within the next 48 hours. Let us know if were right.
> > >
> > > > *Posted by H School, NY on March 19*
> > > > On March 14 we had an Ice Storm and we didn't have any school!!

Two Caveats Related to Observation #3
3A: Increased opportunity for focusing on common interests; decreased control over the kinds of knowledge students explore.

While our research documents several beneficial conversations with students and scientists we also highlight the difficulty such conversations sometimes pose for teachers. First, as students direct more of their knowledge queries to peers and scientists there is less opportunity for the classroom teacher to have a first-hand means of assessing the kinds of content questions and knowledge students explore. In a previous study one classroom teacher mentioned to us that informal assessment in our classroom was more difficult than in traditional programs because the majority of questions the students asked her were procedural rather than substantive (Songer, 1996). In general we recommend software features such as direct cc of students' messages to teachers' mailboxes and support materials for teachers that support their ability to monitor Message Board conversations as a source of informal feedback and student assessment.

3B. Increased opportunity for finding common interests and valuing individual contributions; impossibility of ensuring that all students, or even a majority of students, have this same experience.

As one adult among thirty students many classroom teachers have difficulty guiding individual students' exploration of their own queries across different content areas or areas of focus. Message Boards can provide greater opportunities to compliment the information the teacher can provide and help students find additional personal connections with scientists or other learners. On balance such connections, while valuable, cannot be ensured and inevitably will occur in differential amounts for different students. We encourage classroom teachers to be aware of such inequities and to work towards mechanisms for equitable feedback. For example at the beginning of message board dialogue, teachers might select and publicly share a subset of particularly interesting conversations with all students so that all are provided with at least a small number of meaningful examples and can model their queries towards similar goals.

In Summary

Our research with a suite of coordinated technological tools, including real-time visualization tools and threaded discussion tools, has helped us begin to articulate both the strengths and weaknesses in orchestrating productive social dialogue around emerging technologies. We believe the kinds of dialogue we observe, both on our threaded discussion boards and in our classrooms, provide strong scientific information for the meaningful development of the characteristics of inquiry science as outlined in the National Science Standards (National Research Council, 1996). These include: the development of descriptions, explanations and predictions; communicating scientific explanations to others; using appropriate tools to gather, analyze and interpret data; and a forum for critical and logical thinking about the relationship between evidence and explanations. We admit that we still have a great deal to learn about how to foster a greater amount of this dialogue within our program or other similar programs particularly in classrooms with many obstacles such as the large class sizes and lack of resources often present in Detroit Public Schools, Nevertheless, we are optimistic about the work that is occurring towards greater understanding on these important topics. Providing opportunities for students to go beyond the collection and analysis of scientific data towards the application of their data to the lives and discussion of others is an important context for scientific inquiry worthy of further understanding.

Our work also helps us understand that a systemic learning environment is essential. We believe our tools and activities that fostered productive dialogue was only possible because the dialogue was embedded within a well-coordinated curriculum program (e.g., careful selection of content and related-resources, appropriate sequence of activities, and classroom-supportive technology). The use of specific activities such as the Data Comparison Activity and the Real-Time Prediction Activities provided participants with opportunities to build and revise socially constructed knowledge in a well-established forum where all ideas were productively interpreted and respected.

Our research also outlines areas where message board tools could better support scaffolded learning. Advanced sorting functions (e.g., sorting messages by date, by senders, or by topics) or automatic prompting systems could better support the organization of the social construction of knowledge by others. In addition our work helps us understand that, despite the fact that our tools do so, all tools must work directly with each other i.e. it must be possible to bring conversations and visuals into the same public workspace, and be portable and available from many locations. Our explorations into future designs and hand-held devices will continue to better understand these on-going challenges.

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