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Customized Web Discourse:
Research-Based Suggestions for Message Board Use Within Complex Classroom Environments

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Abstract

As more K-12 students than ever have Internet access through schools and home, educators and policy makers continue to denounce our impoverished understanding of how and when to use Internet-smart technologies towards complex reasoning, such as that involved in inquiry science. As one contribution towards an informed understanding of the pedagogical value of Internet-based electronic discussions and the role they play in complementing traditional classroom discussions, this paper examines the electronic discussions of middle school students as a part of an eight-week, inquiry-focused weather forecasting program. Research questions explored include, What discourse patterns occur on threaded discussion message boards, and how they are similar or different from discourse that occurs face-to-face in traditional classrooms? What kinds of scientific inquiry are visible in these threaded discussions? What roles do students play in knowledge development relative to scientists, teachers and their peers?

To explore these questions, over six hundred electronic messages were analyzed revealing patterns of discourse and turn-taking as well as visible traces of the development of scientific thinking. Results indicate that the conversational turns on the web-boards demonstrated different dialogic patterns than commonly observed in traditional classroom dialogue. In addition, web discussions more closely resembled classrooms discourse patterns considered effective for promoting rich understandings of complex science content, such as reflective tosses (van Zee and Minstrell, 1997). Finally, threaded discussions contained multiple avenues for student customization of queries and follow up responses and led to more cases of customization than is typical of traditional classroom dialogue. We conclude with three research-based conclusions complimented by suggestion for both the productive and unproductive use of web-based discussion tools within complex learning environments such as a middle school science classroom. Our work has implications for both the design of more effective dialogue tools, and the design of activities and teacher support materials that would sustain productive electronic dialogue as an appropriate compliment to traditional classroom dialogue.

Introduction

Can the World-Wide-Web (hereafter called the web) promote learning? Numerous research studies in education appear to focus their queries around an answer to this question, some providing optimistic responses (e.g., Owston, 1997) while others more cautious recommendations (e.g., Roschelle and Pea, 1999).

While much research explores an answer to the question as to whether the web can promote learning, a response to this question is, in our view, too challenging to answer and an inappropriate focus on which to base such research. As with any learning resource embedded in a learning environment, be it textbook, pedagogical approach, professional development model, multimedia resource, or other feature it is difficult, if not impossible, to isolate the effects of that resource on learning outcomes within complex real classroom settings. Therefore we advocate studies that emphasize the role and complimentarily of particular learning features within learning environments. Taking into account the complexity of classroom settings and the social constructivist approaches to learning (i.e. Vygotsky, Bransford et al, 1999) we believe that research focusing on the role of technological and other learning resources within complex environments and as compliments to traditional learning approaches advance our understanding of how to design, support and orchestrate productive classroom learning environments more effectively than research attempting to "prove" the web's utility through the isolation of web use from the support of other learning resources.

In this study we also explore the use of the web within a systemic educational program because of the work previously done in the field of educational technology. Research on how the web is utilized in classrooms document that much classroom uses of web-based tools focus on relatively unproductive web searches rather than supporting students' ability to find, critique, or discuss information effectively (Roschelle and Pea, 1999; Wallace, Kupperman, Krajcik, and Soloway, 2000). These researchers suggest that one reason why the web is often not utilized effectively is because of the common attempt to utilize the web as an individual resource used for an isolated purpose such as searching for specific report rather than as a part of a systemic educational program. Many studies also observe students' web use for a very short period of time and are sometimes disappointed when students' web use does not lead to measurable and important learning outcomes. In contrast we recognize that the orchestration of the use of web learning resources is a complicated process which should, ideally, take into account subsequent redesign of all other components of the learning environment including other software, curricular, information and pedagogical resources. As a result, we investigate the use of the web as a part of careful implementation within a systemic curricular reform project where software, curricula, information, and individuals are synergistically organized into a coordinated eight-week learning environment. In such a systemic change approach to technological innovation, the role of each contributor, including the web message board, is crafted to best take advantage of the subset of learning tasks that it appears well suited for within the larger, dynamic system. Subsequently our research questions and assessment outcomes are adjusted to focus on the role of the web resource within the larger system. In this approach we do not expect to be able to claim that our learning outcomes can be attributed to any one component of the learning environment such as the web.

This paper documents our research on the role of a World-Wide-Web message board system as a part of a comprehensive inquiry-focused middle school learning environment for kids distributed simultaneously across eighty schools in the United States. We summarize our results with three research-based conclusions that provide a rich and complimentary context to our other qualitative results. Questions of focus include,

• What discourse patterns occur on threaded discussion message boards, and how are these similar or different from discourse that occurs face-to-face in traditional classrooms?

• What kinds of scientific inquiry are visible in these threaded discussions?

• What roles do students play in these conversations towards knowledge development relative to mentors teachers and peers?

Related Research

Our research draws from foundational literature in the learning sciences including work on the learning approaches of inquiry (Bransford et al, 1999; White and Frederiksen, 1998) and the social construction of knowledge (Vygotsky, 1978 among others). The learning environment we designed and study, called Kids as Global Scientists: Weather was developed as a context for students' exploration of their own queries and predictions in science through, in part, both the sharing and critiquing of others' work on threaded discussion web message boards. We developed inquiry-focused curriculum that progressively guides students towards the organization of data and information on weather events towards rich definitions of traditional weather concepts such as wind, pressure, temperature, and fronts. In the culminating activity, students apply their more general understandings of these scientific terms towards the predictions and forecasting of current events (For more details on the KGS Weather curriculum see subsequent sections). In our program the threaded web discussion boards, called Message Board, serve as essential sources of feedback for students' evolving content understandings, predictions and explanations. In this study, each of seven message boards was personned by approximately five professional scientists and an average of 600 middle school students.

We selected the study of students' dialogue on the web boards for several reasons. First the research helps us understand that many conceptualize the appropriation of scientific discourse as an essential demonstration and means towards rich scientific understandings (Anderson and Palincsar, 1997; Gee, 1988; Latour and Woolgar, 1986; Rosebery, Warren, and Conant, 1992). Some researchers, such as Lemke (1990) regard "talking science" as an essential component of the process of developing complex understandings such as that involved in inquiry science, and in fact many of the examples of discourse norms discussed in science are identical to norms involved in inquiry: arguing, questioning, describing, and critiquing. Rosebery et al. (1992) state,

> [this] view of science as a discourse helps us to see scientific literacy not as the acquisition of specific facts and procedures or even as the refinement of a mental model, but as a socially and culturally produced way of thinking and knowing, with its own ways

> of talking, reasoning, and acting; its own norms, beliefs, and values; its own institutions; its shared history; and even its shared mythologies. (Rosebery et al. 1992, p 65).

A contrasting view to this social view of scientific literacy is canonical scientific literacy which puts a greater emphases on activities where individual performance is valued over group construction and a greater emphasis is placed on written or didactic presentations of information rather than science learning as the product of socially processes and mediated by systems such as discourse. Adopting a social constructivist view encourages researchers to emphasize processes and products of social dialogue, such as small group or classroom conversations or web discussions as a compliment to more traditional evaluations, such as written pre or post tests for student learning. The study of scientific dialogue encourages researchers to look for measures of understanding that go beyond a purely concept-focused view of science learning towards a view of learning as a process mediated by many influences including culture, learning environment, metacognition, and beliefs about science, among others.

Researchers such as Mehan (1979) have discovered that traditional classroom discourse often follows predictable patterns of Initiation-Reply-Evaluation (IRE). In this pattern, teachers initiate and control questioning and correct answers are emphasized. Several recent studies have identified problems with traditional classroom discourse patterns, such as the silencing of certain populations of students, and have proposed alternative discourse structures to solve these problems (Green, 1983; Hicks, 1996; Lemke, 1990; van Zee and Minstrell, 1997).

The Kids as Global Scientists: Weather Learning Environment

The Kids as Global Scientists: Weather (KGS) learning environment is an inquiry-focused Internet-enhanced atmospheric science program for middle school students. The learning environment consists of a suite of eight weeks of curricular activities, coordinated software, and individuals coordinated across the United States towards the study of concepts such as temperature, wind, pressure, and precipitation in live contexts and with the guided support of online scientists and peers. (Songer, 1996; 1998). Following a set of activities coordinated with others across the United States, students in each site work in small groups of two or three students, and each group specializes in one of four weather topics: Clouds & Humidity, Precipitation, Temperature & Pressure, or Winds.

Designed to build towards students' abilities to make live forecasts about current storms and justify their explanations for their predictions, the program has worked over the evolution of several years to incorporate several key tenets in learning sciences research such as distributed expertise (Brown, Ash, Rutherford, Nakagawa, Gordon & Campione, 1993), socially mediated cognition (e.g., Lave & Wenger, 1991; Pea, 1993; 1994; Vygotsky, 1978), the understanding that young children are capable of complex reasoning and higher-order thinking provided they are supported and guided by activities, tools and individuals who organize complex material for them, regulate the complexity of their questions and information, and provide resources for reflection and evaluation of information (Bransford et al, 1999; Metz, 2000). In addition, we developed our science curricular sequence, with three phases focusing on questioning, exploring and predicting current weather events as one approach to students' development of both a deep understanding of science concepts such as wind, precipitation, temperature and pressure, and as a means of applying their developing understandings through the prediction and examination of current weather events. We developed this approach to emphasize both deep foundation of factual knowledge and a strong conceptual framework as advocated by Bransford and others (Bransford et al, 1999, p. 222-223). For more information on the KGS pedagogical approach and the foundational literature on which the learning environment is based see Songer (1996).

The KGS development team also recognized the capacity of technological tools to serve as a catalyst for meaningful student learning and continues to incorporate approaches to technology into our learning environment that are both powerful and continuously reliable for classroom users. In this program we utilize our own Internet-smart technologies to support the presentation of powerful and current scientific imagery as well as seeded discussions with peers and scientists. Weather data is presented to students in real-time and in a variety of representations using Directorä -created Internet-smart CD-ROM software of our own design (Samson, Master, Lacy, Cole, Lee, Y., and Songer, 1999). The development and use of these tools as a part of an integrated learning environment support additional opportunities for students' knowledge development and questioning.

Since the program began in 1992, our curricular activities, software tools and professional development supports have gone through many cycles of research-focused trial and refinement leading to research insights on student learning (Songer, 1996; 1998), enactment of science programs within complex urban environments (Songer, Lee, and Kam, submitted), and interface design (Songer and Samson, submitted). Our current program focuses on research on science learning amidst systemic urban science reform efforts and student learning and the development of a rich suite of evaluation measures matched to our program goals even as the program is utilized by tens of thousands of students, teachers and scientists with each iteration.

The project activities were also designed to encourage participants to take advantage of an additional unique feature of Internet tools: the power of communication with many distributed first-hand resources, whether local or across the globe (Songer, 1996). Students begin the program by making self-introductions via the web-based Message Board to other students around the world. Throughout the program participants build on these initial introductions through several collaborative Message Board activities including 1) sharing and comparing two weeks of local weather data, 2) sharing and critiquing others' explanations and summaries of weather phenomena, 3) making predictions about others' weather, and 4) sending and responding to weather questions posed by our Weather Specialists, peers or teachers in other locations.

As projects like ours scale to tens of thousands or hundreds of thousands of users we recognize that our program or development staff are not only not capable to guide the learning of so many classrooms and individuals simultaneously but we also know we are not the best resource for providing feedback and resources for the learning of others in context we cannot possible know well. Therefore, another major goal of our learning environment, particularly the KGS Message Board and related research, was to establish resources, a framework and guidance so that students, teachers and scientists could more productively discuss their queries and explanations — whether on the front in Chicago or how to help various learners utilize our visualization resources effectively — and therefore to recognize the power in utilizing each other as resources for weather information, interpretations, first-hand accounts, and professional development tips.

KGS Message Board

The KGS Message Board was designed to work within the KGS learning environment to support knowledge development among a socially constructed, geographically-dispersed group. Like the overall KGS program itself, in designing the Message Board we aimed to build supportive resources for scientific inquiry and the social construction of knowledge (e.g., Lave & Wenger, 1991; Pea, 1993; 1994). We strove to build a learning environment where individual experience and understanding was recognized and shared by others (Songer, 1996; 1999).

In our design of the Message Board, we looked first at how we could utilize the Message Board towards fostering inquiry, particularly the middle school content standards representing a) the identification of questions that can be answered through scientific investigations, b) the use of appropriate tools and techniques to gather, analyze and interpret data; c) the development of descriptions, explanations, predictions and models using evidence, and d) the ability to think critically and logically to make the relationships between evidence and explanations (National Research Council, 1996, p. 145). For example, in the KGS program students process their own and others' weather data through the use of data tables and overlaid weather imagery (see Figure 1) to compare and contrast different sets of data. The KGS Message Board allowed critical discussions about these comparisons and predictions. In this way, the KGS Message Board as a compliment to the live and current weather data provides a forum for the development of descriptions, the interpretation of data, and the fostering of critical and logical conversations with others about current scientific information. In the final weeks of the program, students synthesized both their developing understandings of scientific concepts and their developing understanding of critical interpretation of data towards the prediction of tomorrow's weather conditions.

A second goal of the Message Board was to provide a resource for responsive scaffolding among student and teacher participants. By responsive scaffolding we refer to the ability for knowledgeable learners to post and respond to individual student questions on current topics. We recognized early on that generating authentic discussions on current atmospheric science phenomena was one possible outcome that could be facilitated by the KGS Message Board. "Authentic" questions in our program can be described as questions dealing with both real and near-time weather data and information, as well as questions relevant to the first-hand experiences of other participants (Songer, 1998). Responsive scaffolding has not been well supported by other electronic tools such as email or group conferencing software (e.g., Harasim, 1990; Riel & Levin, 1990; Scardamalia & Bereiter, 1991). We hoped to investigate whether the features of the message board tool, combined with the accompanying supports, could lead to a clear understanding of the productive use of information resources such as individuals and real-time information.

The result of our design was a KGS Message Board separated into seven different discussion groups each of which allowed users to post, read and respond to messages within a community of reasonable size and similar age to themselves. As shown in Figure 2 messages are displayed by threads on each topic allowing users to more easily follow the flow of the discussion (see Figure 2).

<u>Participants and Learning Environments</u>

The KGS program currently contains several thousand learners per eight-week program. Participants are from diverse settings including several public school categories (large urban schools, rural schools, special needs classrooms) as well as classrooms within private schools and an increasing number of homeschool classrooms. Although the target audience was middle school students, our enrollment included 4^{th}-9^{th}grades. On the Message Board, participants were divided into seven groups by age, with each sub-group containing 8-10 schools. A graduate student was assigned to each sub-group to screen for inappropriate messages and to offer support to participants. During the eight weeks of this program approximately 5,000 messages were exchanged. Participants in KGS never met each other, although photos of participants were distributed through a photo essay CD-ROM. KGS participants' social interactions were entirely created and sustained via electronic discourse.

Data Analysis

This section outlines analysis decisions made concerning the unit of analysis, the levels of analysis performed on various messages, the protocols utilized, and the types and numbers of electronic messages coded by each protocol.

Determining unit of analysis. The primary unit of analysis was a message containing from one to several sentences. Each message in a thread of discussion was considered as a turn at talk as in traditional classroom discourse (Cazden, 1988; Mehan, 1979). We chose to consider each message rather than each sentence or each thread as one unit of analysis so that we could most easily characterize discourse structures within electronic dialogues relative to discourse structures in classrooms.

Levels of analysis and protocols utilized. In analyzing electronic messages we looked for protocols which were well suited to our data source. In reviewing electronic messages, we noticed that electronic messages had some features similar to traditional text-based data such as essays or journals, and some features similar to traditional verbal conversations such as interviews, classroom presentations or classroom interactions. Because we shared some theoretical assumptions of several different qualitative analyses approaches, we chose to select two different analyses, Interaction Analysis (Jordan and Henderson, 1995) and Verbal Analysis (Chi, 1997) for the evaluation of dialogue patterns and learning patterns among students' web messages.

Interaction Patterns Analysis

Our first consideration was the analysis of the interaction patterns of electronic discourse. Our methodological assumptions resonated with the underlying assumption of Interaction Analysis (Jordan and Henderson, 1995) which emphasized "the details of social interactions in time and space and, particularly, in the naturally occurring, everyday interactions among members of communicates of practices (p. 41)." For our purposes, we believed Interaction Analysis to be an excellent protocol to help us understand basic web board patterns across several dimensions including time, type of activity, sender, and level of thread.

Time: Our temporal analysis looked at when messages were posted relative to the three phased curricular program. We observed the number and kind of messages posted in the following three temporal phases: a) Weeks 1-2, when students were asked to introduce themselves, b) Weeks 3-5 when students were collecting local weather data and studying various weather concepts, and c) Weeks 6-8 when students were forecasting their next day's weather by synthesizing their experiences and ideas developed during previous weeks of the program.

Type of Activity: In the KGS program we suggested Message Board exchanges at several times throughout the program. Each of these Message Board activities were designed to use conversations with others to expand, evaluate or articulate some aspect of students' developing understandings of scientific concepts. In this analysis we looked at the nature of messages posted relative to the task and goals of the activity at hand.

Sender: Participants of the Message Board dialogue included students, teachers, scientists, and graduate students. In this analysis we wished to observe the patterns of who initiated messages, what kinds of messages different types of participants initiated, and when such messages were posted.

Level of Thread: The Message Board allowed participants to read and respond to other's messages. For this analysis we observed whether a given message was an initial prompt or a response to others' notes as one lens on the patterns of turn taking on the Message Board. Each message was coded regarding the level of thread within a given discussion (i.e. original message, first follow-up message, second follow-up message etc.).

In summary, we employed Interaction Analysis to determine the general patterns of all of the messages posted during this program run (N= 4,464). Patterns were determined in relation to when the message was posted, what activity it was a part of, who posted it, and what turn within the conversation the message represented.

Learning Patterns Analysis

After Interaction Analysis we employed a qualitative methodology that would facilitate a look at the characterization of electronic messages with a particular focusing on learning. We adopted Chi's (1997) Verbal Analysis approach because of the many similarities between verbal and electronic conversations but we modified the protocol in several minor ways. First, in order to seek patterns taxonomies of categories were created related to the kinds of learning activities involved in the curricular task including type of question, general versus customized scientific content, and the presence of familiar conversation. (See Appendix for sample coding categories and examples). Next, data were transformed to a graph that helped us to see certain patterns over time or across categories. With the help of current qualitative analysis software[1] messages could be grouped together or categories could be fused or dissociated depending on research question. For example, we could select messages coded as Type of Question: Situated, then further break these responses into groups of questions authored by students and questions authored by scientists. This kind of grouping would allow us to examine closely the quality, quantity, and character of certain types of message board responses. As such characterizations were made we recognized that it was important to keep the context of conversation available. The process between selecting certain messages and seeking themes, then coming back to the original context to confirm the themes was an iterative and cyclic part of our analysis similar to the manner in which we believe Chi (1997) describes.

After patterns were identified across messages we looked to understand the patterns in a broader context, particularly how individual messages contributed to a larger set of interactions and conversations. In this step we looked at the whole context where the interaction occurred to fully understand and confirm the pattern and the possible sequence or relations between patterns.

Because of the in-depth nature of coding for learning patterns, this analysis was performed on all the messages from one sub-group of schools (Subgroup 3) for a total of 687 messages. We chose Subgroup 3 as their messages were representative of the larger group of schools and participants. In the following sections, we explain the goals of our learning patterns analysis in each of the categories of: Socialization, General vs. Customized Weather Information, and Type of Question.

Socialization. The presence and influence of socialization or invitational dialogue within Message Board messages is one component we believe is essential towards the development of meaningful understandings in science with individuals unfamiliar to yourself, and this is a topic of continued exploration in our project (Songer, 1998). In these data we wished to analyze the presence of social talk as one means of tracking both the pervasiveness of socialization in Message Board dialogue and as one means of continuing to understand the role of socialization in Message Board knowledge development. We also wondered whether the Message Board socialization appeared different in any characteristic ways as compared to classroom discourse. Socialization coding categories and examples are found in the Appendix.

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[1] While any commercial qualitative analysis packages (e.g. Atlas/ti or NUD*IST) or database applications

General vs. Customized Weather Information. The KGS CD-ROM provides students with current weather imagery in age-appropriate, interactive forms (Samson et. al., 1999). In this study we were interested in how students utilized and discussed the current information resources provided by the Internet-smart CD-ROM. The opportunity to discuss current weather events such as tornadoes or severe storms as they are occurring can be a great conduit for productive dialogue and the questioning of simplistic understandings of science concepts (Songer, 1998, 1999). In addition, such a science resource exemplifies the national science standards for a satisfactory resource as it provides students with relevant phenomena, first-hand experiences with phenomena, and a meaningful introduction to concepts (AAAS, 1999). In contrast middle school textbooks cannot provide regionally occurring weather information or live information. In investigating this category we wished to explore and characterize the learning potential, if possible, of a resource that provides both live information, regionally occurring information, and other customizations tailored to the specific needs of small groups of students or individuals. Coding categories focusing on dialogue related to general vs. customized weather information is presented in the Appendix.

Type of Question. Interaction analysis, particularly the level of thread category, suggested that the lack of IRE turn taking patterns in electronic discourse seemed to be related to the type of questions asked on the Message Board. This hypothesis was tested through the addition of a Type of Question analysis that explored patterns in inquiry-based questions and concept-based questions. See the Appendix for coding categories and examples.

Results and Discussion

Interaction Analysis: Time and Type of Activity. In the KGS program, students generated messages throughout all three phases of the eight-week program, but the highest percentage of messages occurred in the first weeks (50.38 % in weeks 1-2, 30.60% in weeks 3-5,

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(e.g. Claris FileMaker Pro or Microsoft Excel) can be used we employed Atlas/ti for this analysis.

and 19.02% on weeks 6-8). The primary uses of the Message Board were the Introductory activity (weeks 1 and 2) and the Real-Time Data activity (weeks 3-5). The introductory activity was designed to help participants get to know each other prior to exchanging and critiquing each other's scientific artifacts.

Interaction Analysis: Sender and Level of Thread. Figure 3 shows the percent of messages by level of thread. As predicted, a large number (40%) of messages were original posting while the remaining 60% were messages posted in response to another note. Figure 4 illustrates the percentage of messages posted by both thread and author (student and adults). Note that while 44% of the total student messages were original messages on a topic thread, only 24% of the total adult-participant messages were original.

Using Interaction Analysis to Examine Discourse Structures. In traditional classrooms, the prevalent structure of discourse follows the I-R-E sequence (Mehan, 1979). In this sequence, most initiations are generated by teachers followed by students' replies and teacher evaluations. Using our level of thread analysis above, we designed a visual map that represents the discourse patterns observed in our Message Board conversations. Figure 5 illustrates both Mehan's traditional discourse pattern as represented in a visual graphic (from Mehan, 1979) and our KGS Message Board discourse pattern illustrated by our data. Note that unlike traditional discourse patterns, the KGS Message Board discourse most often replaced the third-turn evaluation component of IRE with a second reply or new initiations. We believed this occurred because much of the material being discussed was current weather data or patterns that did not have definitive right answers and therefore evaluation of others' responses was less appropriate in these cases. In our Message Board conversations it was not uncommon that several of the participants, including the scientists on occasion, were only able to direct individuals to resources rather than provide actual "answers" to students' queries. While this dialogue might be uncomfortable to some teachers and students, we believe it allowed a greater number of participants an opportunity to share their views without feeling evaluated or criticized.

In reviewing the patterns of Message Board discourse and traditional classroom discourse as illustrated in Figure 5 we conclude that electronic discourse and traditional classroom discourse patterns are not similar in structure. We hypothesize that electronic discourse patterns are more easily be characterized as a two-part sequential structure like an everyday conversation between two or more parties rather than the traditional I-R-E pattern that characterizes classroom dialogue.

Learning Patterns: Social vs. Non-Social Content. Socialization among participants through electronic communication was observed in all phases of the program. In general, about half of the total messages posted on the Message Board contained some socialization or familiarization comments along with scientific information, such as students' descriptions of their school or hobbies. Social comments were more common in the earlier weeks of the program when students were invited to establish some familiarity with each other prior to the exchange and critique of work products. Even though the percentage of socialization-containing messages decreased over time, many students testified that including personal information in their messages proved to be both a fruitful and interesting addition to scientific conversations. As a result, many participants continued to include personal notes with their data and explanations, therefore demonstrating an interest in the lives of the individuals with whom they had developed electronic correspondences.

Learning Patterns: Customized weather information. The KGS learning environment provided real-time weather information through both KGS CD-ROM and the Message Board discussion. Content analysis of messages revealed that 62.4% of the messages that contained weather-related information discussed real-time, current weather information, whereas 30.1 % of those messages discussed more traditional weather information like that found in textbooks. This result illustrates that the majority of the content-focused dialogue on the Message Board discussed current and regionally specific weather information rather than general information. We speculate that discussing regionally and temporally customized information allows students to expand their understandings beyond general textbook oriented definitions. We will discuss additional implications of the potential of customized weather information in student learning in the following section.

Learning Patterns: Type of question. We speculate that Message Board communication can illustrate aspects of students' inquiry processes during their participation in the KGS project. To explore this issue, questions on the Message Board were coded based on the question author and type of question. As we would expect, our results demonstrated that students initiated nearly all of the questions present (91.1%, N=214).

Research-based Conclusions

Our Interaction and Learning Patterns analysis allows us to describe both certain characteristics and frequency of messages present on our Message Board as well as use these patterns to discuss conversation patterns present in relation to traditional classroom discourse. While these data highlight important trends and can begin to answer our research questions on what kinds of inquiry and discussions occur, we provide below three research-based conclusions, supported by examples and evidence, that illustrate our research trends with rich contexts for more complete understanding. We provide these conclusions as complimentary results that, in part, illustrate both the processes and products of social dialogue on these Message Boards.

Conclusion 1. On the KGS Message Board, more student-student communications occurred compared to a traditional teacher-dominant classroom conversation.

Students were active in Message Board discussions. In traditional classrooms, most whole-class discourse is led and dominated by a teacher or a small number of students. The teacher asks questions or explains ideas and a majority of students demonstrate somewhat passive participation such as providing short, yes/no answers or even a nod. According to Bellack

(1966), teachers initiate most classroom talk and in Mehan (1979), 81.1% of total discourse was teacher initiated.

In contrast, on the KGS Message Board students initiated a strong majority (82.8%) of the total messages. In addition, students authored 91.1 % of the original messages containing questions. While students started threads of discussion and responded to other messages, the scientists and the other adults more often responded to students' messages rather than initiating a new thread of conversation.

We expect that our results, in part, merely reflect the manner in which we set up the Message Board activities. The activities specifically asked students to ask questions to scientists and other students to help explore their own queries. On the other hand, even if these results are due, in part, to the nature of the instruction, we still found the Message Board to be a viable media for allowing many different learners to initiate and participate equally in-group discussions.

A second example of the manner in which the KGS Message Board supported student-initiated communications is the result that students had high levels of follow-up responses to others' messages. Perhaps because, in part, of the realization that their messages were read by others and therefore important, many students recognized the value of providing feedback and responses to others through follow-ups. While 60% of the total messages were follow-up messages, 91% of follow up students composed responses. Research by Cohen and Riel among others (e.g., Cohen and Riel, 1989; Redd-Boyd and Slater, 1989) demonstrate that writing for audiences that value individual contributions increases the quality of writing products.

The threaded function of the Message Board also allowed participants to take advantage of some of the inquiry-related benefits of shared cognition. Because the expectation is that all messages might induce a response, authors were careful about the composition of their messages. In many cases, as is documented by Reil (1989) and others, students were encouraged to rethink and revise their original messages. The group construction of ideas through a series of threaded messages helped students to realize that they could seek a greater range of ideas than might be possible in traditional learning environments.

Another example of beneficial student-student communication was the numerous cases where students were able to provide useful information to each other's questions. On the Message Board many questions were regionally specific or otherwise difficult because they focused on current or local events which traditional resources do not address. While other studies show that the most prevalent type of questions asked in classrooms are "text-based questions" that focus on simple definitions from teachers (Scardamalia and Bereiter, 1992), the most frequently asked Message Board question was the "data gathering/collecting questions" (64.0%) asked to fellow students (See Appendix for an example). This difference illustrates that KGS students not only valued the information provided by students who, for example, had first-hand experience with a given storm, but that peer information was an important resource for their knowledge development. Also interesting was the type of questions asked by scientists. Of these, 47.4% scientists' questions were real-time situated questions to students asking students to focus on this relevant and interesting resource of information not available in textbooks.

Collectively, these results support the premise that traditional teacher-dominant discussion patterns were not observed on the Message Board. Rather, KGS students participated in the Message Board discussion more actively and interactively than students might in traditional classroom discussions. These results imply that KGS students, similar to Scardamalia and Bereiter's (1991) "higher agents" are more active in their knowledge construction than might be possible with only traditional classroom discussions. As a result of both the Message Board resource and the KGS curricular activities that provided students with guidance in knowing how to ask and respond to their own queries, students in the KGS program took ownership for their own learning through frequent instances of both raising questions and providing feedback and informational responses to others.

Suggestions for Message Board Use Related to Conclusion One

The high degrees of student initiation and responses on the Message Board suggest several guidelines relative to classroom-based Message Board use. We present two suggestions for Message Board use related to Conclusion One below.

1A. Good for multiple voices; bad for quick decision-making. Our research suggests that threaded Message Boards like the KGS Message Board 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 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 KGS users to reach consensus on a given topic in a short amount of time. While multiple views are easily showcased it is nearly impossible for individuals 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.

We recommend that threaded message boards, as currently configured, take into account this strength and weakness. 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 that the design of new threaded Message Board systems take this suggestion into account, and perhaps, provide different forums or structures, i.e. not hierarchical, for conversations where consensus or quick decision-making is important.

1B. Classrooms might utilize Message Boards when it is valuable for peers to provide feedback on each other's ideas. Because of the opportunity for focused one-on-one or one-to-many feedback with Message Boards sometimes in relative anonymity we suggest that Message Boards might also allow opportunities for students to provide focused feedback to each other's work, particularly when such opportunities cannot be easily orchestrated in traditional classrooms. If Message Boards are to be used in this manner, however, we strongly encourage the development of clear modeling and guidelines for users that would allow productive and supportive feedback by peers.

Conclusion 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 also provided timely and unique kinds of customized information and feedback to guide student scientific inquiry. We discuss three types of customization provided by scientists: regional, temporal, and pedagogical, each illustrated with message board examples.

Regional customization. Many dramatic natural weather phenomena such as flooding, blizzards, fronts or unusual winds occur in local regions as a result of many factors including geography, microclimates, and the unusual combinations of natural events. Most middle school science textbooks sacrifice discussions of local patterns for general definitions or a few well-known historical examples. Believing, in part, of the cognitive value of building scientific understandings from familiar experiences such as local weather patterns, we designed our learning environment to embrace local patterns and to utilize local phenomena to provide the context for the study of general scientific concepts such as wind, temperature, or precipitation. Message example[2] 1 illustrates one instance of this.

> *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!

[2] All participants' names used in this paper are pseudonyms. The underlines were added to illustrate theme of each example.

Message example 1. Regional customization.

Note that in this example the scientist is able to provide specific information to help these students understand the water cycle, a general and important science concept throughout K-12 science curricula using a familiar local geographic feature, the Ohio River. In addition to addressing the students' own query through this rich local example, this illustration is supportive in its response, thereby allowing the students to feel their question was valid and important. Our work with many classrooms demonstrates that even one such productive conversation per student group in the eight-week program can dramatically influence the students' willingness to ask more questions and develop rich explanations of complex science concepts such as the water cycle.

In establishing our learning environment to take advantage of current information, we recognize that studying regionally-specific weather in real-time is often not straightforward in that both these data and their interpretations must be available in real or near time to support students' abilities to track, predict, and explain local events. While the KGS Message Board was developed to serve in this role through daily updates from scientists and continuous asynchronous dialogue with Weather Specialists, the challenge of networks in schools and other factors make us recognize that conversations such as illustrated above still occur too infrequently.

Temporal customization. During our fall program students studied live hurricanes and several tropical cyclones. El Niño was a weather phenomenon that was related to several unusual weather events recently including a very small number of hurricanes one-year in the Atlantic Ocean. While El Niño was a commonly discussed topic in newspapers or on the news, almost no information on El Niño was available in traditional school resources such as libraries or textbooks. Many students posted questions about El Niño on the Message Board allowing our Weather Specialists an opportunity to customize their information so that they could best respond to students' needs on this timely topic. Message example 2 illustrates this temporal customization.

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.
> A2: The winds pushing the currents reverse direction. The reason for the reversal of wind direction is not well understood, and is the topic of mush research.
> A3: It means you will get more precipitation, more than likely--but whether it will be snow or rain, who knows!

Message example 2. Temporal customization.

Pedagogical Customization. Van Zee and Minstrell (1997) coined the term "Reflective Toss" as an description of an alternative classroom discourse pattern where teachers give students increased responsibility for their own thinking (1997, p. 225). A reflective toss sequence consists of a student statement, a teacher question, and additional student statements. In contrast to the IRE evaluation conclusion, the reflective toss sequence supports a third toss of a teachers' question as a means to foster students thinking rather than evaluate it. The "toss" in reflective toss refers to the teacher "catching" the meaning of a student' statement and "throwing" the responsibility of thinking back to students. (Van Zee & Minstrell, 1997, p. 229).

Similar "tossing" of thinking responsibility was observed on the Message Board. On-line weather specialists often asked students real-time, real-life, situated questions. In addition when students asked weather specialists questions, scientists often tossed another question back to students rather than providing the answer. The following message exchange demonstrates how a weather specialist used a real-time event, heavy fog, as an opportunity to present an authentic learning challenge to students. While the first group of students provided a correct response, they did not include any reasons behind their answer therefore encouraging the scientist to continue to prompt these students and others with additional questions and clues rather than answers.

*Posted by **Weather Specialist**, on February 04*

> While you all were sleeping soundly in Houston last night, I was having a tough time with your weather! [My flight] was inbound … and the fog moved in quickly and we couldn't land there! Question: <u>What direction do you think the wind was from when the fog "rolled" in?</u> … Now it's about 4:00 a. m. Central Standard Time and the fog has moved out of the Houston area entirely. The winds are now out of the southwest at about 12 miles per hour.
>
> > *Posted by SFE School, HOUSTON, TX. on February 05*
> > My answer is that <u>the winds came out of the south</u>. I have a question for you: What is the average wind speed in Houston? Would you please reply?
> >
> > > *Posted by **Weather Specialist**, on February 06*
> > > Good answer! Winds from the south and especially the southeast in Houston bring warm, moist air in off the Gulf of Mexico and can cause heavy fog conditions. To answer your question, I'm looking in a book of climatological data. Climatology is the study of weather history. The average wind speed in Houston, Texas is about 8 mph, with the average (or prevailing) direction out of the south-southeast..
> >
> > *Posted by SFE School HOUSTON, TX; on February 06*
> > Hello from the Winds group, sorry Jerry about our weather on flight 101. We don't usually have that much fog. We're guessing <u>the fog rolled in from the north</u>, but then again we're not that smart! How's the weather in central New York? See ya
> >
> > > *Posted by **Weather Specialist**, on February 10*
> > > Hello, the Winds group. Here's a clue to my fog question: <u>Where is the biggest body of water around Houston</u> (I know, too easy, huh?) That's where the fog rolled in from.

<u>Message example 3. Pedagogical Customization.</u>

The participation of scientists in on-going, asynchronous electronic discussion encouraged Message Board discourse that was different from traditional classroom discussions in several ways. Scientists were content resources for the current weather phenomena and they provided valuable information teachers or textbooks cannot often provide. Many weather phenomena are regionally and temporally specific and most textbooks do not provide enough information to help students or teachers understand these specific phenomena. Unlike content resources such as textbooks or websites, KGS scientists provided customized content resources and information based on individual or small group learners' needs. Often scientists' questioning and responses served as a model of scientific reasoning and discourse in its iterative, non-evaluative manner. As students observed the way scientists explain and ask questions about scientific phenomena students could gain understandings of scientific content as well as appropriate information about the talk of science.

Suggestions for Message Board Use Related to Conclusion Two

2A. Expand Expertise Available to Students But Explicit Modeling of Appropriate Responses for All Experts is Required. One of the advantages of threaded discussions is the opportunity to provide new expertise to students besides what is available through traditional resources such as the school library or the classroom teacher. In our study several different types of customization of scientific content were observed, many of which were types of feedback not common in traditional classrooms. On balance, such customization is often difficult to orchestrate for many reasons including a) an inability of some scientists to provide an appropriate level of content help (i.e. too difficult); b) an inability of some scientists to provide appropriate scaffolding (i.e. provide only direct answers rather than guiding students towards an answer), and c) an inability of teachers to easily provide helpful scientist 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 the research project personnel should provide guidance training to on-line experts to maximize the possibility of beneficial conversations.

2B. Use Message Boards for complimentary modeling and mentoring to that possible 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 serves as a complimentary resource for teachers such as the instances in our program when peers in other locations provided helpful feedback to others' research questions. On balance, use of the Message Board for complimentary modeling and mentoring is also difficult to implement fairly and valuably in a classroom of different learners and therefore also requires careful organization and monitoring.

Conclusion 3. Students' blend of personal and scientific information on the KGS Message Board established productive relationships, fostered on-going collaboration, provided a context for learning science and otherwise allowed highly productive and motivating learning to occur.

Early socialization was essential in establishing collaboration. We believe that early social interaction among participants allows individuals who did not have face-to-face contact to establish credibility and identity between themselves so that they could experience productive scientific relationships with other participants. Understanding this need to establish social norms with others prior to knowledge development dialogue (e.g., Bruckman, 2000; Cohen and Riel, 1989; Riel and Levin, 1990), we designed our first Message Board activity to focus on establishing productive relationships through focused introductions. We also recognized that encouraging some personalization and social components in their introductions were an essential component in setting up a productive scientific relationship. Message 4 illustrates one characteristic set of introductions. Through these, participants began to recognize differences among geography and weather as well as form social bonds through the recognition of common or diverse interests and profiles. Note that the questioning about temperatures in Guam was not a teacher-instructed task, but a demonstration of students' genuine interest.

> *Posted by MB School, Guam on February 17*
> Hello, My name is Don and my school is very small; it only has ten kids. We are trying to learn as much about the weather as possible. There are only two people in the temp. group. Andy is 12 years old and he enjoys scuba diving, soccer, and video games. Don is 13 years old and I like to play soccer, football, and video games. Usually the temperature is about 83 degrees F.
>
>> *Posted by GM Middle School, VA on February 20*
>> Hello from Virginia, USA. What is it like to live in Guam? It must be wonderful with the weather and all. Where do you live in Guam? What school do you go to? Got to go. Nice talking to you. Hope to talk to you again.
>>
>>> *Posted by MB School, Guam on February 23*

> This is Don, I live in a small village and it is like a suburb for the island. The weather is not all that good when you live here for a long time, but the best time is right after a typhoon (that is like a hurricane). The weather is too much the same, I mean if you come in the dry season the weather is almost always going to be dry. See we only have two seasons, the wet and the dry. I go to MB School, which is a very small school. It only has ten students but we are getting one more.

Posted by GM Middle School, VA on February 20:
Hello, my name is David. I go to GM Middle School in Virginia. I'm eleven years old. I like playing video games and playing sports. GM Middle School is a lot bigger than your school; the Middle School has about 400 people. It's colder here. <u>Today it's really warm- 53 degrees. Normally it's in the 30's in the winter. What season is it in Guam? How hot does it get all year? I'd really like to know.</u>

<u>Message example 4. Early socialization in establishing collaboration</u>

Early socialization by sharing diverse experiences was a key factor in sustained collaboration. The large number and diversity among KGS participants provided a rich range of scientific resources, including personal experiences, than typically available in one homogenous classroom environment. Participants from various locations brought their personal experiences into the conversation. For example, students in Hawaii and Michigan were surprised by the differences in seasonal temperature fluctuations. After communicating with Hawaiian students, the Michigan students' conceptions of weather were expanded to include a range of patterns.

Early social connection was also a key factor that supported sustained collaborations throughout the program. For example, during the Data Comparison activity, students in Indiana noticed that 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. This message exchange also shows an example of sustained communications between two groups of students. As they obtained new information, it led them to ask new questions. One student in Guam, Don, posted an interesting introductory message (see Message 3). This contrasting weather to most students in the United States caught many students' attention. As a result of these introductory exchanges, these sets of students had built a history of communication before they exchanged scientific data. A study by Bruckman (2000) addressed the importance of context of scaffolding in addition to the content of scaffolding. She argued that who provides the scaffolding (either computers or peers who share common interests) is as important as the content of the scaffolding itself. Similarly early social connections among KGS participants prompted rich scientific discussion throughout the program.

> *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. What is the coldest it has ever been at your school?
>
> > *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. The coldest temperature we have is somewhere in the 60s. 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. Do you have tornadoes where you live?
> > >
> > > > *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. Do you know what a waterspout is?

Message example 5. Early socialization and sustained collaboration.

The novelty of first-hand experience of dramatic science events. Severe weather such as hurricanes, tornadoes, and floods were popular topics of discussion among participants. Whenever unusual weather phenomena happened, the participants who were experiencing the phenomena reported their first-hand experience on the Message Board, and these experiences drew other's attention to the phenomena resulting in a context-rich learning opportunity for many participants. 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. Such conversations provide excellent contexts for the ability of students to think critically and logically to make the relationships between evidence and explanations come alive, as outlined in the National Science Standards (National Research Council, 1996, p. 145), but also help students understand a version of the nature of science which has science as a matter integrated with, rather than separated from, everyday life.

> *Posted by SFE School, TX on February 12*
> Today in Houston it is pouring rain and there is a flash flood. All of the windows are foggy.
>
> > *Posted by GM Middle School, VA on February 20*
> > Hi to people from Houston, How's the flood doing? How is everyone in Houston? ….Got to go! Hope to hear from you soon! I'll write back. Bye-Bye!
> >
> > *Posted by GM Middle School, VA on February 20*
> > Hi, How bad is the flood? Is it still flooding there? Tell me about everything.
> >
> > > *Posted by SFE School, TX on March 03*
> > > Hi, The flooding wasn't that bad where we live. Pasadena got hit by a tornado a few weeks ago. We have had some rain and it's been overcast... It was really cool and the weather was pretty good. At night you can see all the stars. Well, write back soon.

Message example 6. First hand experience of dramatic science events.

Participating in science practice through productive exchange of both personal and scientific information. In the following example, a student question, What is your favorite cloud? prompted a great deal of rich discussion that, once again, provided a context for students' knowledge development and scientific inquiry.

> *Posted by GV School, NH on January 29*
> What's your favorite cloud?
>
> > *Posted by Weather **Specialist**, on January 29*
> > My favorite cloud is the cumulonimbus. Do you know what type of weather is associated with a cumulonimbus cloud? 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??

Message example 7. Learning content through personal experiences.

The ability of the scientist to take this invitation and guide student thinking in meaningful ways illustrates his fostering of the development of models and explanations of complex science concepts. The students' personal question that led to a scaffolded dialogue that invited students to gather, analyze, and interpret data towards a meaningful goal. The dialogue served as an instance where the scientist used this communication as an opportunity to connect science to the students' everyday life experiences, thereby providing authenticity for students' inquiry.

The Real-Time Data activity allowed students to analyze current weather data using our visualization tool culminating in making inquiry-focused predictions of weather in another classrooms' city. Message 8 shows how electronic discourse encouraged participants to practice scientific inquiry through cycles of prediction making and observation/evaluation with other community members.

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 "Blue Skies" 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!!

Message example 8. Participating in science practice.

Through these communications, students had greater opportunities to go beyond the collection and analysis of scientific data; they had the opportunity to apply the data to their everyday life and to the lives and discussion of others. While the application of scientific data is advocated by the national standards (National Research Council, 1996) and other policy documents, students often have little chance to do this kind of inquiry in traditional classrooms (Songer & Linn, 1991). Our research suggests a learning resource within a learning environment, the KGS Message Board, that provides opportunities for students' development of their own queries and connections to their own experiences as advocated by the national standards and other documents.

Suggestions for Message Board Use Related to Conclusion Three

While it is difficult to determine the extent to which the Message Board influenced the development of students' concept understandings our results illustrate several different types of benefits possible when science talk that blends personal and scientific narratives compliments traditional science instruction.

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 conversation sometimes poses 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 for students to compliment what the teacher can provide and 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.

3C. Message Board dialogue provides opportunities for the development of knowledge that is rich in both information and personal narratives, that we call "organic knowledge"

Our research in this study, as in previous studies (i.e. Songer, 1998) illustrates several examples where the Message Board fostered dialogue that wove knowledge rich in both personal and scientific information. In many cases this rich dialogue encouraged sequential follow-up and highly interactive discussions among students, resulting in greater opportunities for students to interpret information, identify their own queries, and think critically about evidence and explanations much in the manner advocated by national reform documents such as the National Science Standards (National Research Council, 1996). In our research group we have come to use the term "organic knowledge" to describe the foundational knowledge, in our case scientifically based, that consists of a mixture of personal stories, individual customizations and evidence and information. We distinguish organic knowledge from declarative or fact-based knowledge common in middle school science, such as that most commonly found in textbooks and many other resources, including many web resources. We believe our research studies continue to articulate both the strengths in fostering students' development of organic knowledge, and the conditions and recommendations that allow productive development and application of such knowledge. We also believe that organic knowledge is worthy of further exploration in that it exemplifies many dimensions of the kinds of knowledge described as valuable for student knowledge construction, such as knowledge that supports students' own queries in science or the critical evaluation of scientific information. Concerning scientific inquiry, the development of organic knowledge is fostered through many of the conversations common on Message Boards as students grapple with characteristic inquiry activities including: interpreting data; developing descriptions, explanations and predictions; and responding critically towards the development of their own evidence and explanations.

Analyses of KGS Message Board communication between students and scientists helped us begin to understand the characteristics of electronic discourse as one example of the scaffolding and collaboration benefits possible when message board tools are utilized as part of a carefully implemented systemic reform program. Our research illustrates that the character of discourse on Message Boards is different from traditional classroom discourse in both content (i.e. content information infused with personal connections, called organic knowledge) and interaction patterns.

We found that a well-coordinated curriculum program (e.g., careful selection of content and related-resources, appropriate sequence of activities, and classroom-supportive technology) could support social relationships between participants that fostered productive personal/scientific talk, even within an eight week program. Specific tasks such as the Introductory activity and the Real-Time prediction-making activities provided participants with opportunities to build and revise socially constructed knowledge.

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. Furthermore, as the scale of the electronic community increases, management of the huge volume of messages became a daunting challenge.

In spite of the increasing interest in the use of Internet-based technology in the classroom, research on the effects of these technologies on learning and teaching are still limited. We have just begun to systematically examine the effects of newly emerging technologies, the kinds of knowledge fostered and the support systems required for productive learning. This study of electronic discourse and the resulting suggestions for use of Message Boards can serve as a research-based start towards an expanded understanding.

References

American Association for the Advancement of Science. (1999). Heavy Books Light on Learning. Project 2061 Press Release, September, 1999.

Anderson, C. W., & Palincsar, A. S. (1997). Canonical and sociocultural approaches to research and reform in science education: The story of Juan and his group. The Elementary School Journal, 97(4), 357-381.

Bellack, A. (1966). The Language of the Classroom. New York: Teachers college Press.

Bransford, J., Brown, A. & Cocking, R. (1999). How People Learn : Brain, Mind, Experience, and School. Washington D.C.: National Academy Press.

Brown, A. L., Ash, D., Rutherford, M., Nakagawa, K., Gordon, A., & Campione, J. C. (1993). Distributed expertise in the classroom. In G. Salomon (Ed.), Distributed Cognitions: Psychological and Educational Considerations (Learning in Doing - Social, Cognitive, and Computational Perspectives). New York, NY: Cambridge University Press.

Bruckman, A., (2000). Situated support for learning: Storm's weekend with Rachael. The Journal of the Learning Sciences 9(3), p. 329- 372

Cazden, C. B. (1988). Classroom Discourse: The Language of Teaching and Learning. Portmouth, NH: Heinmann.

Chi, M. T. H. (1997). Quantifying qualitative analyses of verbal data: A practical guide. The Journal of the Learning Sciences, 6(3), 271-315

Cohen, M. & Riel, M. (1989). The effect of distance audiences on students' writing. American Educational Research Journal, 26 (2), 143-159

Gee, J. P. (1988). Literacy, discourse, and linguistics: Introduction. Journal of Education, 170(1).

Green, J. L. (1983) Exploring classroom discourse: Linguistic perspectives on teaching-learning processes. Educational Psychologist, 18, 180-199

Harasim, L. (Ed.). (1990). Online Education: Perspectives on a New Environment. Praeger Pub Text.

Hewitt, J. (1997) Paper presented at the National Association for Research in Science Teaching (NARST) Annual Meeting.

Hicks, D. (1996). Discourse, learning, and teaching. Review of Research in Education, 21, 49-95.

Jordan, B. & Henderson, A. (1995). Interaction analysis: Foundations and practice. The Journal of the Learning Sciences, 4(1), 39-103.

Latour, B., & Woolgar, S. (1986). Laboratory Life: The Construction of Scientific Facts. (2nd ed.). Princeton, NJ: Princeton University Press.

Lave, J., & Wenger, E. (1991). Situated Learning: Legitimate Peripheral Participation. Cambridge, MA: Cambridge University Press.

Lemke, J. (1990). Talking Science: Language, Learning and Values. (Vol. 1). Norwood, NJ: Ablex Pub. Corp.

Mehan, H. (1979). Learning Lessons: Social Organization in the Classroom. Cambridge, MA: Harvard University Press.

National Research Council. (1996) National Science Education Standards. Washington, D. C. National Academy Press.

Owston, R. D. (1997). The World Wide Web: A technology to enhance teaching and learning? Educational Researcher, 26 (2) 27-33.

Pea, R. (1993). Learning scientific concepts through material and social activities : Conversational analysis meets conceptual change. Educational Psychologist, 28, 265-277.

Pea, R. (1994). Seeing what we build together: Distributed multimedia learning environments for transformative communication. The Journal of the Learning Sciences, 3(3), 285-299.

Redd-Boyd, T. M. & Slater, W. H. (1989). The effects of audience specification on undergraduate's attitudes, strategies, and writing. Research in the Teaching of English, 23 (1), 77-109

Riel, M., & Levin, J. (1990). Building electronic communities : Success and failure in computer networking. Instructional Science, 19, 145-169.

Roschelle, J., & Pea, R. (1999). Trajectories from today's WWW to a powerful educational infrastructure. Educational Researcher, 28 (5), 22 – 25+

Rosebery, A., Warren, B., & Conant, F. (1992). Appropriating scientific discourse: Findings from language minority classrooms. Journal of the Learning Science, 2(1), 61-94.

Samson, P., Masters, J., Lacy, R., Cole, D., Lee, Y., & Songer, N.B. (1999) Hold the Java! Science Activities via Networked Multimedia CD-ROMS. Interactive Multimedia Electronic Journal of Computer-Enhanced Learning.

Scardamalia, M., & Bereiter, C. (1991). Higher levels of agency for children in knowledge building: A challenge for the design of new knowledge media. The Journal of the Learning Sciences, 1(1), 37-68.

Scardamalia, M., & Bereiter, C. (1992). Text-based and Knowledge-based questioning by children. Cognition and Instruction, 9(3), 177-199.

Songer, N. B. (1996). Exploring learning opportunities in coordinated network-enhanced classrooms: A case of Kids as Global Scientists. The Journal of the Learning Sciences, 5(4), 297-327.

Songer, N. B. (1998). Can technology bring students closer to science? The International Handbook of Science Education. K. Tobin and B. Fraser (Eds.) The Netherlands: Kluwer.

Songer, N. B. (1999). Technology and Scientific Inquiry: Are there unanticipated consequences to relevant science? Paper presented at the annual conference of American Educational Research Association, Montreal, Canada.

Songer, N.B, Devaul, H., Hester, P., Crouch, S., Kam, R., Lee, H.S., Lee, S. Y., Vekiri, I. (1997) Kids as Global Scientists: Weather!: An Eight-Week Inquiry Curriculum for Middle School Atmospheric Science.

Songer, N.B., Lee, H. S., Kam, R (submitted) Urban Science Classrooms Amidst a Technological World. Submitted to the Journal of Research in Science Teaching.

Songer, N. B., & Linn, M. C. (1991). How do students' views of science influence knowledge integration? Journal of Research in Science Teaching, 28(9), 761-784.

Songer N. B. & Samson, P. (2000) Internet-Enabled Multimedia: Research-Driven Designs of A Classroom-Focused Approach. Paper submitted to Interacctive Learning Environments.

van Zee, E., & Minstrell, J. (1997). Using Questioning to Guide Student Thinking. The Journal of the Learning Sciences, 6(2), 227-269.

Vygotsky, L. S. (Ed.). (1978). Mind in Society: The Development of Higher Psychological Processes (Edited by Cole, M. John-Steiner, V. and Souberman, Eds.). Cambridge, MA: Harvard University Press.

Wallace, R., Kupperman, J., Krajcik, J., and Soloway, E. (2000) Science on the Web: Students online in a sixth-grade classroom. The Journal of the Learning Sciences 9(1) 75-104.

White, B. Y., & Frederiksen, J. R. (1998). Inquiry, Modeling, and Metacognition: Making science accessible to all students. Cognition and Instruction, 16(1) 3-118

Appendix. Data Coding Categories and Examples

Level One Coding Category: Type of Activity

A1 Introductory Messages

1. Hi, We're from Canada. This town is surrounded by mountains so therefore we have lots of animals such as: deer, bears, cougars, woodpeckers, ...

A2 Ask Questions to the Weather Specialists

- Could you please send us a list of GOOD web pages/sites having to do with clouds and/or humidity?

A3 Real - Time Data Analysis

- Our weather maps here showed very low barometric pressure in your area. How low was your barometric yesterday (3/6) during your bad weather?

A4 Weather Forecasting

- We think you will have rain within the next 48hours

Level Two Coding Category: Socialization

S0 No Social Content: only science related information

- When do you think your next severe storm will happen again?

S1 Some Social Content: individual interests, hobby or descriptions of a school, etc.

- Elisa's hobby is playing sports (field hockey, soccer, softball & water skiing) and doing things with friends.

Level Two Coding Category: General vs. Customized weather information

WI0 No weather information offered (or question only)

- How’s weather in your area?

WI1 General weather information: Climate or weather pattern

- Our usual weather here is rainy and wet

WI2 Current weather information: real-time,

- It snowed last night, then in the morning it rained so the snow turned into slush

WI3 Both current and general weather information

- We usually have very cold winter, but this year we haven’t had a snow day yet.

Level Two Coding Category: Type of Questions

Inquiry-based Question

Q1 Data gathering/collecting question: asking experience, observation, measurement, and recording data

- Does it snow where you live? What kind of precipitation do you get

Q2 Data processing question: comparing, contrasting, classifying data, and identifying anomalies

- Is it usual that there is no winds 2 weeks in a row at this time of year? or is there always no winds except for some? does the no winds have to do with where you are located on the globe?

Q3 Data synthesizing question: predicting, hypothesizing, generalizing, and applying to the real world

- When do you think your next severe storm will happen again?

Concept-based Question

Q4 Text-based question: asking definition, basic information

- What exactly is pressure?

Q5 Knowledge constructing question: requires explanation of scientific principles, theories

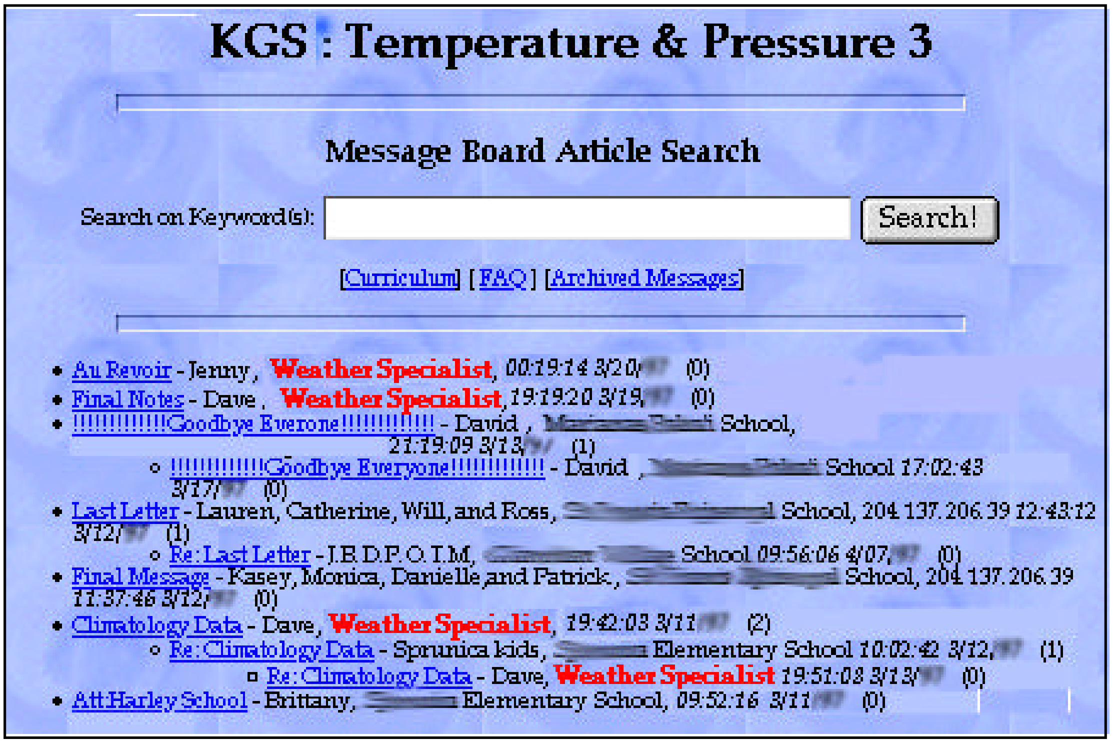
- Why are some clouds white and some are gray?

Q6 Situated Question Real-time/ real-world question

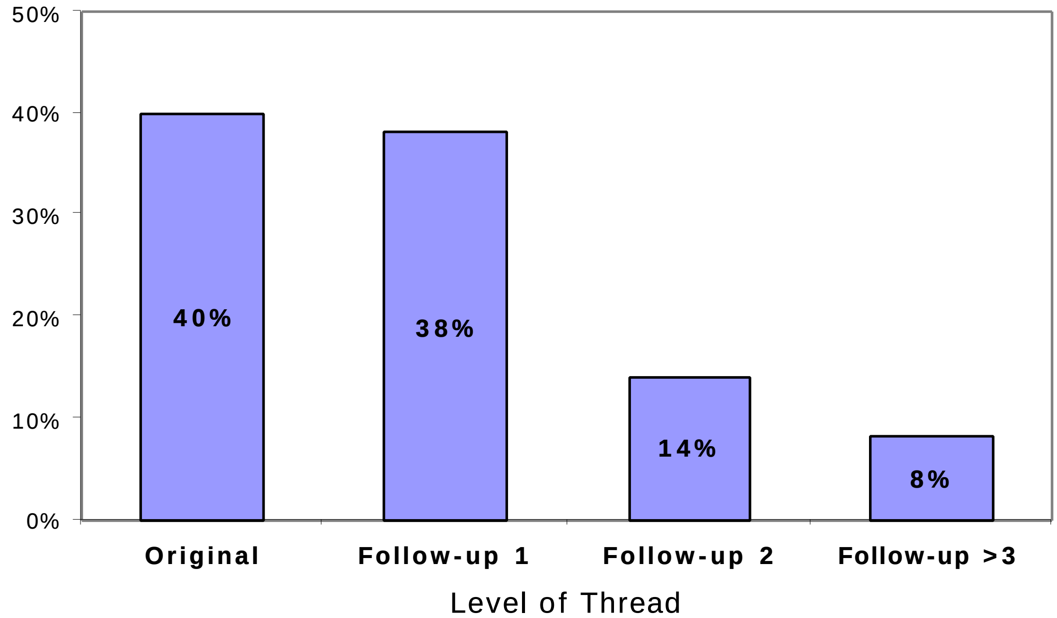
- I know that 3/4 of tornadoes occur in the u.s. Why is that? and why do most tornadoes occur in "Tornado Alley"?

Figure 1: KGS Screen Shot with overlayed data (Pressure and Wind data overlay)

<u>Figure 2</u>. KGS Message Board.



<u>Figure 3.</u> Percent of messages by level of thread (N= 4,464)



<u>Figure 4.</u> Percentages of thread-level messages posted by adults (n= 769) and students (n=3,695).

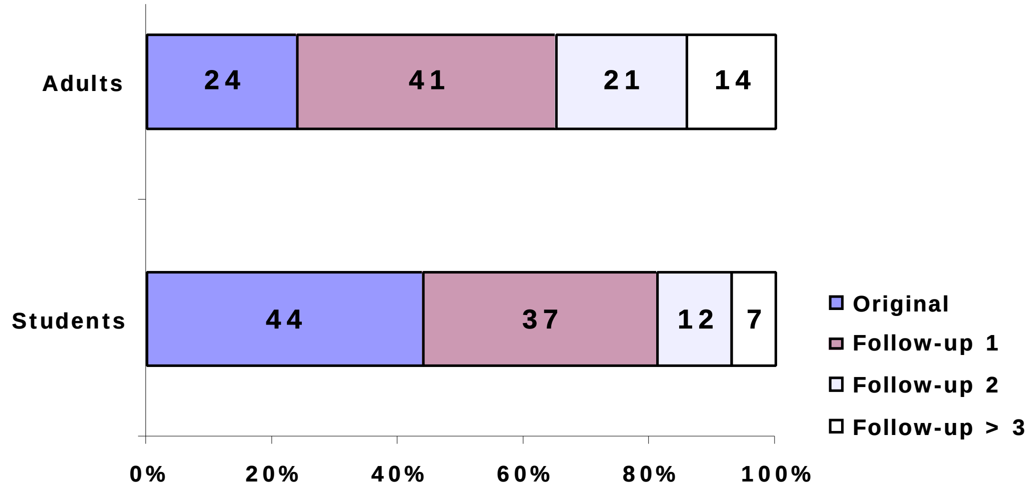


Figure 5. Traditional classroom (Mehan, 1979) vs. KGS Message Board discourse pattern.