Published in the *Journal of Science Education and Technology*,
March 1997, v.6 no.1 p23-36.

Sherry Hsi

Christopher M. Hoadley

Graduate Group in Science and Mathematics Education (SESAME); University of California at Berkeley; Berkeley, California USA.

Address correspondence to:

Sherry Hsi

SESAME

4533 Tolman Hall #1670

University of California

Berkeley CA 94720-1670

(510) 642-9717

hsi@garnet.berkeley.edu

Running Head: Productive Discussion in Science

Productive Discussion in Science: Gender Equity through Electronic Discourse

Sherry Hsi

Christopher M. Hoadley

Graduate Group in Science and Mathematics Education (SESAME)

University of California at Berkeley

Berkeley, California USA

Abstract

Electronic discussion tools can have several advantages over classroom discussion to support productive learning conversations in science. This paper describes how an electronic collaborative discussion tool called the Multimedia Forum Kiosk (MFK) enabled equitable learning opportunities in scientific discourse: generating explanations, revising ideas of others, and asking questions. Studies compared gender differences in participation between class discussion and MFK discussion, as well as examined three different formats for electronic discussion: anonymous, attributed, and attributed with authority participation. Results indicate that in all discussions, 78% of the students contributed in electronic discussion compared to only 15.3% participation in class discussion. Females participated *more* than males in electronic discussion, and less than males in classroom discussion. Girls report feeling less stifled when participating in an electronic medium where anonymity is an option. All electronic discussions were characterized by high levels of scientific conceptual content, elaborations, and question-asking. Students generated a repertoire of models for phenomena, asked content-focusing questions, and provided causal explanations using MFK. Implications for future research and design of electronic discussion tools are discussed.

Keywords: Gender, Collaborative Learning, Science Education, Computer-Mediated Communication

Introduction

Classroom discussions are an important vehicle for learning, and continues to be the main alternative for lecturing in classrooms today (Philipsen, 1993). Previous research indicates discussion can prompt reasoning in students when guided by teachers or trained peers (Barnes and Todd, 1977; Inagaki, 1981; Minstrell & Stimpson, 1995; Roschelle, 1992). Social interactions during discussion can also help elicit conceptual content in talk (Resnick et al, 1993; diSessa and Minstrell, 1994). Discussions can help students expand their repertoire of ideas, consider the views of others, and motivate the revisions of ideas (Brown and Palinscar, 1989; Linn et al, 1994; Strike and Posner, 1985, 1992). Peers in discussion can also play an important role in contributing to a groups' expertise and distributing responsibility for learning and remembering new ideas (Brown et al, 1993, 1994; Newman et al, 1989; Pontecorvo, 1993). Comprehension among peers often improves because other peers place ideas in familiar student-like terms (Songer, 1993).

However, classroom discussion can stifle debate, privilege teachers, and silence females. In class discussion, rather than considering views of others, students often misconstrue evidence, misinterpret ideas, and accept authoritative views without personal reflection during discussion (Pea & Gomez, 1992). Without time to reflect on ideas presented in a discussion, students do not change their ideas or revise their knowledge. Ideally, students should make connections between scientific concepts and relate these concepts to personally relevant problems instead of adopting the view of an authority (Linn & Songer, 1993; Schank & Cleary, 1995).

Another caveat of class discussion is gender inequitable participation. Female students, as compared to males, contribute less to class discussion and frequently encounter criticism based on the normative view that science is a male domain (Baker, 1987; Morse & Handley, 1985; Sadker & Sadker, 1985, 1994). Teachers often sustain inequitable class participation, calling on boys more often than girls in math or science classes (Becker,

1981) and elaborate more on males' responses than female responses in large group discussion of scientific concepts (Jones & Wheatley, 1990; Tobin & Garnett, 1987). Although teachers may be unaware of gender inequities in the classroom, their students are not. Females express fear about participating in whole-class discussions, as well as other activities requiring discussion (Guzzetti & Williams, 1996). Students may feel social pressure to take on the views of their peers while in a group setting, yet not change their personal views or make the effort to understand the views of others (Janis, 1972; Linn & Burbules, 1993). The result is that mixed gender groups in science may consistently disadvantage girls (Madhok, 1992).

Can electronic discussion improve learning opportunities and balance gender participation in science classrooms? Electronic discussion can differ from class discussion in several important ways. Although electronic discussion may lack verbal or gestural actions from face-to-face discussion, the electronic medium can be designed to prescriptively capitalize on social features of discourse. Electronic discussion can also reduce social inhibitions and gender differences typically found in class discussion. For instance, authorship of comments can be attributed or hidden depending on the situation. Electronic discussion also can afford graphical representations to help contrast alternative accounts of scientific events and multiple viewpoints. Moreover, unlike class discussion, electronic discussion can be asynchronous to allow more careful reflection by participants, less interruption, and better recognition of individual contributions than in a large group discussion. Thus, electronic discussion can be tailored to be quite different from traditional class discussion.

Previous studies on electronic communication have found that the communication medium can impact gender equity. Access to an electronic bulletin board allowed women in a community to voice opinions in public on-line forums (Rogers et al, 1994). Other researchers also found that females were perceived as more cooperative and less exploitative than men when social cues such as gender were provided by the discussion tool (Matheson, 1991). However, not all examples of on-line communication have been positive. Some negative examples include women being ignored, ridiculed, or attacked in electronic discussion networks and virtual chat rooms (Herring, 1992; Quittner, 1994). Some speculate that anonymity of the public electronic medium would further aggravate participation of women (Tannen, 1994). Unfortunately, on-line networks are currently used predominately by men (90% for the World-Wide Web in 1993, according to Pitkow and Recker's Second Annual WWW Survey, 1994), which may exacerbate gender problems in commonly used electronic discussions, such as Internet newsgroups or on-line chat programs.

This paper describes research using an electronic discussion tool called the Multimedia Forum Kiosk (MFK). We investigate some differences between the use of this tool in a classroom and in-class discussion. In addition, we examine how certain aspects of the MFK interface influence participation. The role of attributing comments to individuals and the role of authority participation in discussion are investigated in three formats for MFK discussion: all comments attributed to their authors, all comments attributed plus authority participation (class teacher), and all comments anonymous. This study is intended to illuminate and identify key features of electronic discussion for supporting gender equitable opportunities and productive discussions in science.

Definition of a Productive Discussion

In this work, we define productive discussion as talk that incorporates the voice of all students, expands students' repertoire of ideas, and increases students' ability to distinguish between ideas. A discussion is considered productive when all students participate actively, students generate comments containing a repertoire of scientific ideas, and in a group, students elaborate their own ideas, and propose new ideas. Productive discussion is also seen as a way to promote scaffolded knowledge integration (Linn, 1995).

A productive discussion in science is characterized by several features. First, all the participants, boys and girls, contribute to the conversation, and work collaboratively to solve a problem or issue. Each participant gets an opportunity to be heard and listens to the views of others. Each view is also backed with evidence and explanation.

Second, a productive discussion is one that capitalizes on the social aspects of interaction and downplays the negative aspects. The recognition of peers, facilitators, and authorities in science can help or hinder the credibility of arguments. Social forces also help scaffold the process of learning, monitoring, and reflection in scientific discussion. The environment of a productive discussion is cooperative: students are comfortable and willing to share, revise, and critique their own ideas, as well as the ideas of others. Students also do not hesitate to pose any questions to the group, and feel their questions are worthy of discussion.

Lastly, a productive discussion in science capitalizes on distinguishing among views to encourage sense-making. Multiple hypotheses are being proposed, supported, evaluated, criticized, and refined. In the process of discussion, individuals try to make sense of anomalies or competing theories, an important step in science knowledge acquisition (Chinn & Brewer, 1993). They may search out new information, ask questions, or solicit explanations while trying to reconcile their view with alternate views. Although one might argue that a discussion is productive when all students provide the scientifically accepted answer, we believe a discussion is more productive when students can distinguish and elaborate their ideas and generate a repertoire of ideas. When explanations are incorrect, or based on interpretations of everyday experiences, a first step in changing their ideas is to make them explicit by articulating their own views in discussion, seeing a repertoire of ideas, then selecting, and converging on correct ideas among the repertoire generated. (For a theoretical discussion of model generation, differentiation, and convergence, see Linn, 1995; Hunt & Minstrell, 1994, have had great success with this approach.) By motivating students to reflect on their ideas, formulate explanations for scientific events, analyze arguments, and pose meaningful questions, a productive discussion can better prepare learners to address complex problems in science.

Designing a Productive Discussion using MFK

This paper reports on research using the Multimedia Forum Kiosk, an electronic discussion tool used to identify which features of electronic discussion support productive discourse in science (Figures 1-3). In particular, we investigated the role of comment attribution and authority participation in discussion, as well as gender differences in participation.

Engineering productive discussions is a multifaceted task. As with any piece of software, numerous factors influence adoption and use of collaborative technology (Hsi & Hoadley, 1994; Perin, 1991; Riel & Levin, 1990). Here we describe the Multimedia Forum Kiosk in the context of middle school science. Middle school students were posed experientially-based science questions and allowed to collaboratively generate ideas, theories, and possible solutions.

Unique Features of the Multimedia Forum Kiosk

Several collaboration environments and discussion tools have been developed for knowledge building, note sharing, inquiry-based and problem-based learning (Edelson, Pea, and Gomez, 1996; Guzdial et al., 1996; Scardamalia & Bereiter, 1991). MFK differs from these collaborative learning environments in that it provides two unique, structured representations about a specific topic in science. MFK permits students to explore multimedia evidence for their views, allows teachers to control and to monitor the contributions of authorities, and supports anonymous as well as personalized contributions to discussion (Hsi et al, 1995; Hsi & Hoadley, 1994). Using the Kiosk Author's Toolkit, instructors can also design discussion topics, organize the composition of student discussion groups, and capture comments.

Multimedia Instantiations of Everyday Scientific Phenomena

Multimedia consisting of digital video, still images, or sound tracks are used to illustrate the discussion topic and stimulate discussion in MFK. Multimedia provides everyday examples involving scientific principles and draws on students' intuitive ideas in science. For instance, students might be asked how a bike reflector works, or where heat flows when a soda at room temperature is placed into a plastic ice chest with frozen blue ice. Research indicates that students who have a systematic understanding of their everyday experiences and start reasoning from their intuitions can develop more sophisticated repertoire of models (diSessa, 1988; Linn, 1992).

Representing Discussion Graphically

A unique feature of MFK not found in other discussion tools are two graphical representations of discourse called the *Opinion Area* and the *Discussion Area* (Figures 1 and 2). Students may browse position statements of other participants in the Opinion Area, or add to an on-going argument in the Discussion Area.

Opinion Area

To demonstrate individual interpretation in collaborative discussion, the Opinion Area permits students to make only one position statement, which they may revise over time. Small pictures of participants' faces are used as icons to show the identity of contributors and reinforce individual responsibility for formulating a personal perspective. Individual contributions are also more easily identified in a large discussion. By browsing the Opinion Area, participants gain a Gestalt view of the other participants and their views.

Discussion Area

To help support critique and recognize anomalies, the Discussion Area features *argument maps* displaying disagreements, questions, and lines of reasoning. To add to a conversation in the Discussion Area, students indicate how their contribution relates to points made by others through linked comments and semantic labels (AND, OR, BUT, I.E., ?, ...) (Figure 3). These labels, loosely based on discourse theory (Bales, 1970) are designed to force students to compare their own ideas to those of others and to reflect more carefully on arguments made before extending the discussion. Moreover, the prompting provided by the semantic labels is intended to privilege students in discussion. Students jointly share the responsibility for asking questions and monitoring peer discussion. MFK provides not only a way for students to construct and communicate their ideas to others which is an important design goal for engagement (Shneiderman, 1992), but also leaves an artifact of discussion in the argument maps. The permanent record of discussion left by MFK is intended to allow for more careful review of arguments compared to face-to-face discussion.

Identity and Anonymity

Although we intentionally used face icons of individuals to represent comments so students would take more responsibility and commitment for their views, MFK also allows anonymous contributions for students who feel less secure about their ideas, students who want to voice controversial polarized views, or students who want to gain credibility for their comments by hiding their own identity. Anonymous contributions are represented with one of several cartoon identities, or simply as "anonymous" with a "photo not available" icon. Anonymity provides security for students who do not like to take social risks in learning. Communication researchers indicate that participation increases with de-individualization of a personal identity (Lea & Spears, 1991). In science discussion, students typically believe teachers are looking for the "right answer" and that they need to know the "right answer" before they can participate. Teachers can use anonymity to encourage students to generate their own perspectives and voice potentially inaccurate ideas rather than parrot a teacher's response.

Asynchronous learning

Because participants enter comments one at a time, students can take advantage of the asynchronous discussion as it develops in that it allows more time for reflection and knowledge revision. Students who are less assertive in class discussion can make a contribution at their own pace. Asynchronicity also allows for students from different class periods to hold conversations with each other, expanding the scope, time, and place where productive discussions can occur.

Knowledge Revision and Reflection

MFK supports text entries as the principle component for discussion. The text that students enter for their comments provides a visible and persistent representation of their ideas. Students reflect on their views when they react to others' views, and they may revise their views based on questions or evidence supplied by their peers in discussion. These comments can be revisited by the topic author or others. Although text-based discourse is less spontaneous than in-person, voice, or video, it engages students in writing, an added benefit for student learning (Bereiter & Scardamalia, 1986; Flowers et al, 1992).

Methods: Using MFK in a Classroom Context

Middle school students from a public school participated in an experimental physical science curriculum developed by the Computer as Learning Partner project (Bell, Davis, & Linn, 1995; Linn, 1992). Six class periods with a total of 165 students used MFK during an 18-week curriculum that covered topics in heat, light, sound, and energy. Every four weeks, a new topic from the curriculum was posted on MFK and discussed by 11 groups of 15 students each. For example, students viewed a text description and digital video of a Styrofoam ice chest containing both frozen "blue ice" and a soda at room temperature, and discussed "Which will have heat flow out of them?".

In MFK, students earned class credit for participating in discussions, but not for the correctness of their ideas. To get full credit, students needed to make at least three MFK comments during a four week period. Students were also expected to make at least one contribution to class discussion.

The MFK software ran on a pair of Macintosh computers at the side of the classroom; students took turns using the software during breaks between classes, outside school hours, or during free time in class. No time was specifically devoted to using the system other than an in-class demonstration the first time the system was introduced to the students.

To explore attributed and authority influence in discussion, equal numbers of boys and girls were randomly assigned into one of three MFK discussion conditions for each topic: anonymous, attributed, or attributed plus authority participation. For the anonymous condition, all participants were assigned unique cartoon identities. For the attributed condition, students' names and photos were displayed, but comments made by researchers or teachers were anonymous. In the attributed plus authority condition, all comments were attributed to named photos, and the classroom teachers and researchers were prominently identified as science authorities. An authority entered an opinion in the Opinion Area, as well as participated in the discussion, while the authorities made few comments in the attributed condition. An electronic log recorded all comments and time-stamped all writing and reading interactions.

Eight video and field observations of class discussion led by the classroom teacher served as comparison to MFK discussion.

Results

Results indicate electronic discussion in MFK can support productive discussion as evidenced by two overall findings: (1) electronic discussions were gender equitable compared to class discussion, yielding more participation by students overall compared to class discussion and (2) the quality of these discussions was high: students collaboratively generated a repertoire of models, asked relevant questions, and constructed explanations for their peers.

Result 1: MFK discussions are gender-equitable

Discussion in the Multimedia Forum Kiosk was compared to in-class discussion. Field and video observations indicate students made more contributions in MFK discussions compared to class discussion (MFK: 78%, Class: 15.3%). Gender participation followed normative patterns: more boys than girls called answers during class discussion, and the same small group of students raised hands to participate in class (M: 16.5%; F: 14.1%). Only a small percentage of students were actively participating in class discussion. This classroom behavior is not entirely attributable to the limited amount of time available in class. While many students in class discussion spoke repeatedly, the MFK, in which 16% made more than their required comments, did not shut out others from contributing.

Boys also interrupted more than girls and raised their hands more frequently (Figure 4). Not surprising, boys were also typically the first hands to be raised. The classroom teacher, who has received awards for improving science education for girls, would attempt to compensate by calling on girls when possible, but even so, boys ended up participating more in class discussion. In comparison, gender participation in electronic discussion was equitable ($t = .53$, $p = .59$).

We also looked for interactions between gender and the type of discussion. While there were no between group differences in number of comments made by gender in anonymous, attributed, or attributed plus authority discussions ($F(2, 437) = .059$, $p = .9430$; see Table 1), on the average, girls participated *more* than boys in both reading the comments of others and making entries in all MFK discussion formats.

Interestingly, girls and boys differed in their tendency to comment anonymously when this option was given to them. In previous research, conducted the year before in the same classroom, girls made significantly more anonymous comments than boys when students had a free choice of anonymity on each comment they made, ($z = -2.388$, $p = .0169$), and conversely boys made significantly more attributed comments ($z = -2.388$, $p = .0169$).

Why do girls participate in MFK discussion?

To gain more insight into why girls participated more in electronic discussion, students in MFK discussions (from two consecutive semesters where MFK was used) were surveyed and interviewed. Comments from written surveys given at the end of the semester were compiled and grouped based on reasons why students did or did not prefer MFK discussion over traditional class discussion (Table 2). Both boys and girls mentioned the benefits of asynchronous discussion: more time to revise knowledge and reflect, and access to participants from other class periods. However, the primary reason cited by girls (37.5%) was that with MFK their ideas could be heard without ridicule or embarrassment. Girls felt their contributions to science discussion could be judged on merits other than social status and reputation. Moreover, they felt less stifled in an electronic medium where anonymity was an option.

> "You can say what you really believe and not worry about people looking at your (sic) funny or making fun at you." (girl1)

> "You don't have to feel so stupid or embarrassed." (girl2)

> "You don't have to be embarrassed of what you are saying so you don't have to worry about saying something wrong." (girl3)

The primary reason cited by boys was the asynchronous nature of MFK (21.9%), and secondary reasons were anonymity and ridicule.

> "In a face to face discussion it would be pure chaos if that many people talked at once." (boy1)

> "You can express a opinion without being interrupted."(boy2)

In contrast to girls, several boys did not perceive any benefit to electronic discussion over class discussion (8 out of 78 boys' responses, compared to 0 out of 73 girls' responses). Comments from more confident and vocal students indicated they were surprised that their peers had something interesting to contribute and knew something about science in MFK.

> "Something that surprised me most was that people who I talk to outside of class (and they say they don't like science) respond to the kiosk, and they have a really interesting answer."

> "Many of the shy kids of my class expressed what they thought about the topics really well!"

> "It surprised me that most people seemed to know and really understand what they were talking about on the Kiosk."

In summary, electronic discussion in MFK appears to be more productive for supporting gender equitable discussions in science because it offers anonymity, less interruption, and more time for reflection than class discussion.

Result 2: Electronic discussion resulted in high quality participation

Three aspects of comments generated by students were analyzed: 1) the number of scientific facets or models generated, 2) the quality of questions asked, and 3) the level of elaborations/explanations generated. Using these three measures for productive discussion, the quality of electronic discussion in MFK was found to be high.

1) How well do students collaborative generate a repertoire of ideas?

In analyzing students' conceptions, we developed a coding scheme to include the various ideas expressed in the discussion based on the facets approach (Minstrell & Stimpson, 1986). Each comment was coded as having a scientific conception if it contained phenomenological ideas such as "metals get hotter than wood when heated", partial scientific principles, or full principles such as "the more heat energy added to an object, the more its temperature will change". The coding scheme was originally developed to look at students scientific ideas, models, and principles by examining student portfolio projects (Clark, 1996), and was expanded to include ideas expressed in electronic discussion.

In all the discussions, students were able to generate multiple viewpoints and even were willing to put forth conceptions that were inaccurate and incorrect.   Table 3 shows the number of different facets students were able to generate in each discussion and the average number of facets each group of 15 expressed. In addition, students read many facets as well, which we hope helped expand their personal repertoire of models.

To illustrate, excerpts from typical MFK discussions from 180 students in 6 science classrooms generated at least four different views on heat transfer; all four views appeared in most discussions. Here, students were asked to discuss which objects (frozen blue ice and room temperature soda in a plastic ice chest) will have heat flow out of them.

> <u>Heat flow model</u>: " I think that the soda loses heat energy. The blue ice absorbes (sic) the heat energy. When the blue ice is in the freezer, the freezer absorbs the energy from the blue ice."

Cold flow model: "When you take something out of the freezer you can *see* the cold. If you take out something that is room temperature, you can't see the heat," " I feel that the blue ice will give off cool energy keeping the soda cold..."

The Replacement Model: "The heat energy will flow out of the soda and it will be replaced by cool energy."

The Temperature Model: "I think that none of the objects will have heat energy flow out of them, because the ice will just change the surrounding temperature to the temperauter (sic) of the ice. So basically, the temperature will just change."

Can students ask good questions and critique peers?

To see if students were integrating information from their peers and learning to differentiate between models, we looked at the questions asked by students and how well they critiqued the ideas of others. To measure the quality of question asking, two coders independently categorized student questions into 5 kinds of questions (Table 5). Questions coded as content-specific were on-topic, based on scientific content, and directed at getting an explanation or knowledge advancing. For example, here students critiqued views of others and posed meaningful questions to help peers resolve anomalies.

> "If the ice is making everything (cokes and air) colder, then how does the ice melt? Where does the heat come from to melt the ice? " (rating = content-specific)

> "How does heat energy effect the amount of cold energy is allowed in and out of an object? Can energy flow in and out of an object simultaneously?" (rating = content-specific)

“Is blue ice just like regular ice, or is it colder?” (rating = content-specific)

Overall, the quality of questions improved, where more content-specific questions were asked in later discussions (See Figure 5). We found that students began to differentiate between which ideas are more appropriate for each situation. Over the course of a 18 week semester, student-generated questions in MFK improved both in quality and quantity over time. Not only did the proportion of questions in the student comments go up (see Figure 6), but the total number of student questions surpassed the prompting of the adult participants by the end of the semester (Figure 7). Students appeared to have taken over some responsibility for knowledge advancing. (Scardamalia & Bereiter, 1991). Moreover, there were no gender differences in the number of questions asked by boys and girls.

Can students elaborate their ideas well and provide peer explanation?

Finally, students' MFK comments were evaluated for the quality of elaboration (Table 6). The quality of elaboration for each comment was rated on a scale from zero to four: (0 = off task, 1 = short answer, 2 = limited elaboration, 3 = elaboration with one backing or evidence, 4 = extended elaboration with multiple backings). Comments like "I agree" or "the ice" were coded as short answer. Limited elaborations were statements with no backing such as "the soda gets cooler". An example of an extended elaboration with multiple backings or evidence is “I feel that the blue ice will give off cool energy keeping the soda cold. When you take something out of the freezer you can see the cold. If you take out something that is room temperature, you can't see the heat." is coded as an extended elaboration.

Not only did students' comments contain a repertoire of scientific ideas, students demonstrated they could explain and support their ideas as evidenced by their elaborations (Table 4). 41.6% of the comments had multiple backings for their ideas, and 38.5% of comments had at least one backing.

Discussion

We have described our discussion tool, the Multimedia Forum Kiosk, and how a productive discussion can improve integrated learning (expanding a repertoire, posing questions, generating explanations) and gender-equitable participation.

Students not only participated more in electronic discussion compared to classroom discussion, they also took initiative to ask questions articulating both what they already know and what they need to know. Students appeared to have taken over some responsibility for facilitating the discussion and focusing the scientific content of the discussions. Similar to those successes of modeling question-asking in small group discussion (Brown & Palinscar, 1989), we speculate the process of question-asking modeled by the teacher or researcher in the earlier electronic discussions helped improve the quality of questions asked by students later on (Figure 5-7). Further studies are needed to examine which kinds of questions or prompts by the teacher succeed in an electronic format.

We were not surprised by the lack of gender differences between the discussion formats for attributed and attributed plus authority. Attributed discussions plus authority contributions were more similar to attributed discussions without the authority because students only read the contributions by an authority when he or she was someone familiar to them in person first (e.g. student teacher rather than unknown scientist). Thus, social context was an important factor in deciding which comments to read of others. Also, some students report they chose not to read authority comments altogether because students considered it "cheating" if they didn't try to construct their own explanation.

When comparing anonymous discussions with attributed discussions, we also found no gender differences in participation. One explanation for the lack of difference between discussion formats might be because students were rewarded for their participation through homework credit, so any potential differences between conditions may have been eliminated. Although one might expect participation of girls to increase with anonymity because girls could enter all their comments discretely and experience less stress when participating privately, girls would also participate in attributed discussions because they were more conscientious about accomplishing school work. However, girls made significantly more anonymous comments than boys when students, and conversely boys made significantly more attributed comments when they had free choice of anonymity on each comment they made. We speculate that boys, especially in middle school, might prefer to be recognized and take credit for their answers, and thus choose to be attributed in electronic discussion.

Girls report it was important that they could enter a comment anonymously first and later enter in an attributed contribution when they were more confident about their answer. Girls preferred the electronic discussion format over class discussion because they could formulate a contribution at their own pace, ask “stupid questions”, and revise or "take back" what they said previously. Boys participated more in attributed discussions because they did not find the need to be anonymous. Thus, a choice of attribution or anonymity should be a feature to enable productive electronic discussion.

In our study, the teacher was trained to facilitate gender equitable discussions using techniques such as waiting until many hands were raised before calling on a student, soliciting many viewpoints, and calling equally on both genders where possible. However, classroom interaction patterns were normative: boys were more assertive in trying to get attention or called-out responses without being recognized by the teacher, while girls waited to be called on and raised their hands less frequently. In an electronic discussion format, the asynchronous nature of communication removes interruption thus removing a barrier for girls in discussion, but nevertheless, students must exercise autonomy in joining the discussion, whether electronic or face-to-face.

Our research suggests electronic discussion can be designed to support productive learning conversations, to capitalize on public and private aspects of social interaction, and to foster collaboration and gender equity in science discussions.

It appears that design of communication media can have real impact on social variables such as gender equity and peer respect. Teachers have greater opportunity to structure classroom collaboration using the computer to mediate communication and make it productive for all students. By allowing students to communicate independently of time, space, or even identity, class discussion may be made to transcend the social limitations of face-to-face interactions. Face-to-face interaction and computer-based communication each have unique features which shape the communication taking place in the medium. We do not advocate replacing electronic discussion with class discussion, but suggest that electronic discussion is one way to involve all students equitably in discussion. By studying how electronic collaboration works, we can gain better insight into how to get more students involved in the science discourse, and conversely, the research on classroom discourse can inform the design of electronic communication systems. Regardless of whether the communication is on- or off-line, understanding the factors that influence participation in productive discussion is essential for promoting social interaction as a teaching and learning tool. In summary, electronic discussion opens up new possibilities for supporting gender equitable discussions in science making them more productive than class discussion.

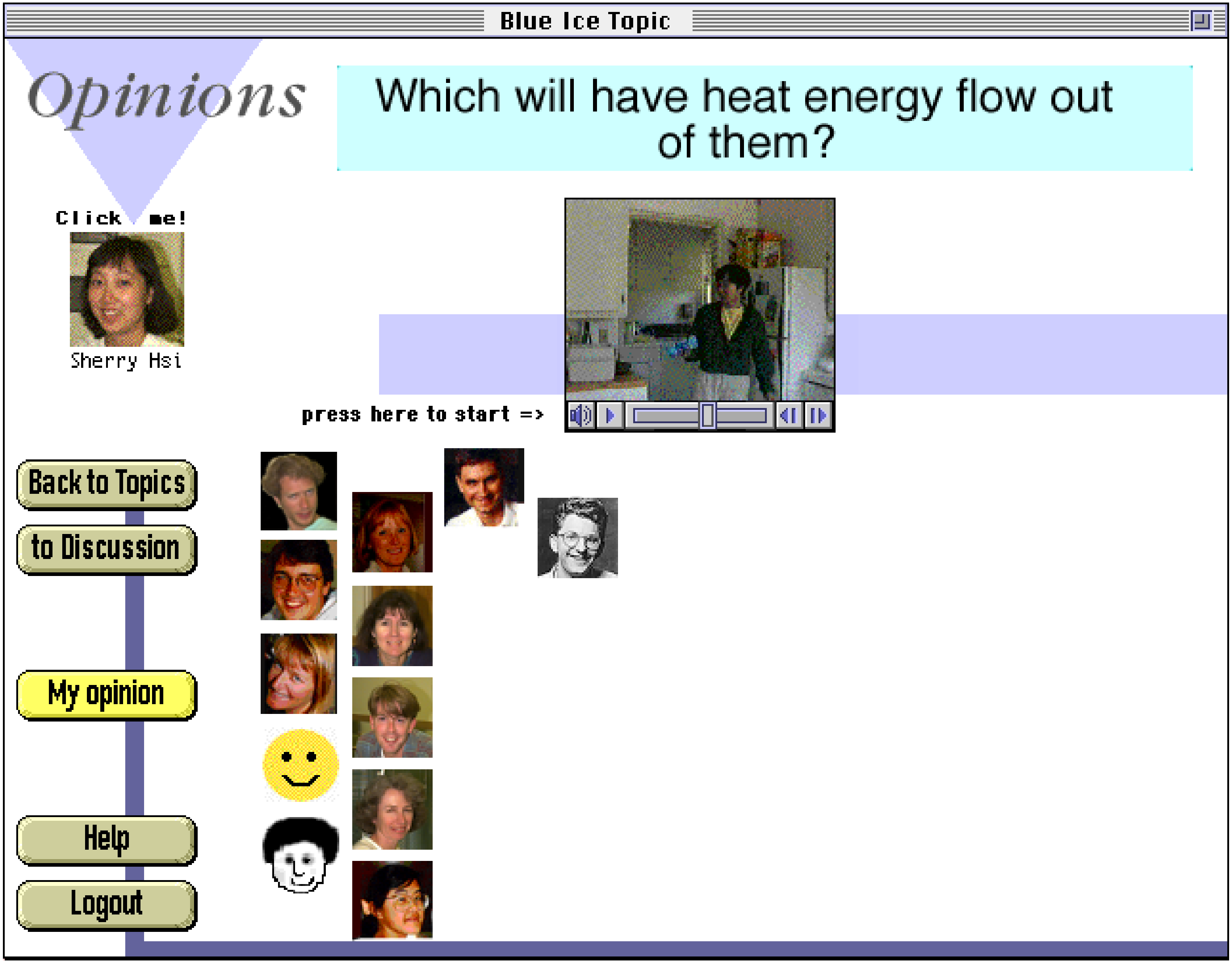
Implications for Future Research

Elsewhere, we have proposed a theory of socially relevant representations (Hoadley, Hsi, & Berman, 1995a) for designing user interactions and interfaces. Participants in discussions make use of social context information and social structure in interpreting the information they encounter. They also consider the impact of information they provide (such as their identity) for future social interactions. We propose that through design and experimentation, interfaces for communication may be designed to improve communication through judicious use of social context information. Furthermore, such research may aid in development of guidelines for implementation of electronic discussions, informing such choices as group size, task structure, and role of the discussion in the larger context.

To better understand the needs of on-line communities, collaborative processes, and how social context information can be used to support learning in science, several factors are being explored in the context of a World Wide Web-based version of MFK called the *SpeakEasy (Hoadley, Hsi, & Berman, 1995a, 1995b; Hoadley and Hsi, 1996)*. SpeakEasy is currently being pilot tested in the context of the Knowledge Integration Environment Project (Bell, Davis, & Linn, 1995) with middle and high school science students, as well as the CoVis project (Pea & Gomez, 1992; Edelson & O'Neill, 1994) with teachers from forty different science classrooms. Information from this testing will allow better understanding toward specifying goals for designing future systems to support on-line collaboration and equitable discussion, as well as help refine our theory of socially relevant representations.

Acknowledgments

This material is based upon research supported by the National Science Foundation under grant No. EEC-9053807 and RED-9453861. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation. The authors would like to gratefully acknowledge the support and collaboration by Prof. Marcia C. Linn, Prof. Alice Agogino of the NSF Synthesis Coalition, Douglas Kirkpatrick of Foothill Middle School, the Knowledge Integration Environment Group, and Computers as Learning Partner Group at the University of California at Berkeley.



Blue Ice Topic
Opinions
Which will have heat energy flow out of them?
Click me!
Sherry Hsi
press here to start =>
Back to Topics
to Discussion
My opinion
Help
Logout

Figure 4: Gender Differences in Class Discussion Participation

Figure 6: Proportion of questions in student comments

Figure 7: Comparison of Student questions versus Adult question prompts

Table 1: Gender differences in Discussion conditions

KIOSK condition		ENTRIES mean SD	T, p-value	READING	T, p-value
Attributed	M	1.53, 1.31	.055, p = .89	4.30, 5.21	.055, p = .96
	F	1.53, 1.28		4.40, 5.18	
Anonymous	M	1.54, 1.32	.463, p = .64	3.87, 4.88	1.23, p = .22
	F	1.66, 1.59		5.27, 7.54	
Authority	M	1.86, 1.67	.125, p = .90	4.77, 8.22	1.24, p = .22
	F	1.90, 1.73		6.70, 6.30	

Table II: Summary of Coding for "What makes MFK better than Face to face discussion?"

Factors that make Kiosk better than class discussion	MALE	FEMALE	MALE	FEMALE
Not as Embarrassed, Ridiculed, Nervous	13	24	17.8	37.5
Non-confrontational	9	5	12.3	7.8
Anonymity	13	15	17.8	23.4
Asynchronous talk	16	10	21.9	13.7
Access to Different Viewpoints	4	7	5.4	10.9
Idea revision and Reflection	6	7	8.2	10.9
Not any better	8	0	10.9	0
Other	9	5	12.3	7.8
TOTAL	**73**	**64**	**%**	**%**

Table III: Mean Number of Unique Facets by MFK topic

MFK Topic	# comments	# of students	# of Unique ideas	# correct ideas per Kiosk	Mean # ideas per group of 15
#1 - light	142	163	15	7	5.09
#2 - heat & temp	124	164	13	5	6
#3 - heat energy	133	164	25	9	7.36

Table IV: Quality of Elaboration for MFK conditions

	Coding Value	ATTRIBUTED %	ANON %	AUTH %	OVERALL %	OVERALL #
off task	0	1.37	1.47	1.33	1.38	7
short answer	1	3.65	5.15	4.67	4.34	22
limited	2	13.24	20.59	18.67	14.2	72
single backing	3	38.81	41.18	42	38.46	195
multiple backing	4	42.92	31.62	33.33	41.62	211

Table V: Coding for MFK Questions

0. NO CODING. Unable to code. Uncertain of category.

1. OFF TASK. Question is unrelated to discussion or irrelevant.

Example: ""Why does Joe dye his hair?"

2. NON-SPECIFIC QUESTION. Question is related to topic, but doesn't follow from the comments before it.

Example: "White walls are better at scattering light."

"Why do people like mirrors on the walls?"

3. COMMENT AS QUESTION. Phrasing a comment as a question. Question used to set up a response by same person. Question follows from previous comment.

Example:

"Who would like white walls anyways? I think that..."

"Don't you think that mirrors would be better? Mirrors would ..."

4. GENERAL PROMPT. Request for clarification. Aimed at knowledge-focusing, but no specific mention of content.

Example:

"What are you saying?"

"Could you be more specific? Give me an example."

5. CONTENT SPECIFIC QUESTION. Question is directed at getting an answer or explanation. Question found an anomaly and seeks to correct it. Question is on-topic. Direct knowledge advancing.

Example:

"Why do you think that ice has heat energy in it?"

"Does wood have any heat energy in it?"

"How can cold energy and heat energy exist at the same time?"

Table VI: Depth of Explanation Scale

0. NO CODING. Unable to code. Uncertain of category.
1. IRRELEVANT. Unrelated to providing explanation. Ex. "You've got the right idea"
2. LIMITED DESCRIPTION. Isolated fact or information. Statement without backing or restates problem. No causal explanation. Ex. "Mirrors reflect light." "White walls are better."
3. CAUSAL EXPLANATION. "....because...." " if.... then...." "when .... then...." Ex. "Rooms are brighter because the room is white"
4. ELABORATED EXPLANATION. Links scientific principles to example. Ex. "Judging from our experiment however, I think that white would be better. This is because it scatters light all directions rather than focusing only in one direction."

References:

Baker (1987). Sex differences in Classroom Interactions in Secondary Science. *Journal of Classroom Interaction* 22(2), 6-12

Bales, R. F. (1970). *Personality and interpersonal behavior.* New York: Holt, Rinehart, and Winston.

Barnes, D. and F. Todd (1977). *Communication and Learning in Small Groups.* Boston: Routledge and Kegan Paul.

Becker, J. R. (1981). Differential Treatment of Females and Males in Mathematics Classes. *Journal for Research in Mathematics Education, 12*(1), 40-53.

Bell, P., Davis, E. A., & Linn, M. C. (1995). The Knowledge Integration Environment: theory and design. In *CSCL 95: Proceedings of the Computer Support for Collaborative Learning Conference*, Bloomington, Indiana, Oct. 17-20, 1995.

Bereiter, C., & Scardamalia, M. (1986). Levels of inquiry in writing research. *Review of Educational Research, 13,* 259-282.

Brown, A. L., & Palinscar, A. S. (1989). Guided, cooperative learning and individual knowledge acquisition. In L. B. Resnick (Ed.), *Knowing, Learning, and Instruction*, (pp. 393-451). Hillsdale, N.J.: Lawrence Erlbaum Associates.

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*, (pp. 188-228). New York: Cambridge University Press.

Brown, A. L., Palinscar, A. S., & Armbruster, B. B. (1994). Instructing comprehension-fostering activities in interactive learning situations. In H. Mandl, N. Stein, & T.

Trabasso (Eds.), *Learning from Texts*, (pp. 757-787). Hillsdale, NJ: Lawrence Erlbaum Associates.

Chinn, C. A., & Brewer, W. F. (1993). The role of anomalous data in knowledge acquisition: a theoretical framework and implications for science instruction. Review of Educational Research. 63(1):1-49.

Clark, H. C. (1996). Design of performance based assessments as contributors to student knowledge integration. Unpublished dissertation. University of California at Berkeley.

diSessa, A. A., & Minstrell, J. (1994). Cultivating conceptual change with benchmark Lessons. In J. G. Greeno & S. Goldman (Eds.), *Thinking Practices,*. Hillsdale, NJ: Lawrence Erlbaum Associates.

diSessa, A. A. (1988). Knowledge in Pieces. In G. Forman & P. Pufall (Eds.), *Constructivism in the Computer Age,* (pp. 49-70). Hillsdale, NJ: Lawrence Erlbaum Associates.

Edelson, D. C., & O'Neill, K. (1994). *The CoVis collaboratory notebook: computer support for scientific inquiry.* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA, April, 1994.

Flowers, L., Schriver, K. A., Carey, L., Hass, C., & Hayes, J. R. (1992). Planning in writing: the cognition of a constructive process. In S. Witte, N. Nakadate, & R. Cherry (Eds.), *A Rhetoric of Doing. essays on written discourse in honor of James L. Kinneavy*. Carbondale, Illinois: Southern Illinois University Press.

Guzdial, M., Kolodner, J., Hmelo, C., Narayanan, D.. Carson, D., Rappin, N., Hubscher, R., Turns, J. and Newstetter, W. (1995) Computer Support for Learning through complex problem soving. Communications of the ACM, 39 (4), April, 43-45

Guzzetti, B. J., & Williams, W. O. (1996). Gender, text, and discussion: examining intellectual safety in the science classroom. *Journal of Research in Science Teaching*, *33*(1), 5-20.

Herring, Susan. (1992) Gender and participation in computer-mediated linguistic discourse Paper presented at the Annual Meeting of the Linguistic Society of America, Philadelphia, Pennsylvania, Jan. 9-12, 1992. Available from ERIC, Educational Research Information Clearinghouses as ED345552.

Hoadley, C. M., and Hsi, S. (1996) A theory of collaborative networking in the science classroom. Paper presented at the Annual Meeting of the American Educational Research Association, New York City, April, 1996.

Hoadley, C. M., Hsi, S., and Berman, B. P. (1995a) Networked Multimedia for Communication and Collaboration. Paper presented at the Annual Meeting of the American Educational Research Association, New York, NY, April. Available from ERIC, Educational Research Information Clearinghouses as ED382181.

Hoadley, C. M., Hsi, S., Berman, B. P. (1995b) The Multimedia Forum Kiosk and SpeakEasy. Demonstrations program of ACM Multimedia '95, San Francisco, CA, Nov. 5-9, 1995. New York: ACM Press.

Hsi, S., Hoadley, C. M., & Linn, M. C. (1995). Lessons for the Future of Electronic Collaboration from the Multimedia Forum Kiosk. *Speculations in Science and Technology, 18 Dec* (4), 265-277.

Hsi, S., & Hoadley, C. M. (1994). Designing an interactive multimedia kiosk as a tool for collaborative discourse, reflection, and assessment. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA, April, 1994. ERIC #-

Hunt, E., & Minstrell, J. (1994). A cognitive approach to the teaching of physics. In K. McGilly (Ed.), *Classroom lessons: integrating cognitive theory and classroom practice*, (pp. 51-74). Cambridge, Massachusetts: MIT Press.

Inagaki, K. (1981). Facilitation of knowledge integration through classroom discussion. *The Quarterly Newsletter of the Laboratory of Comparative Human Cognition, 3*(2), 22-28.

Janis, I. L. (1972). *Victims of groupthink: A psychological study of foreign-policy decisions and fiascoes*. Boston, Massachusetts: Houghton Mifflin.

Jones, M. G., & Wheatley, J. (1990). Gender differences in teacher-student interactions in science classrooms. *Journal of Research in Science Teaching, 27*, 861-874.

Lea, M., & Spears, R. (1991). Computer-mediated communication, de-individuation and group decision-making. In S. Greenberg (Ed.), *Computer-supported Cooperative Work and Groupware*, 155-173. San Diego, California: Academic Press.

Linn, M. C. (1992). The computer as learning partner: Can computer tools teach science? In K. L. Sheingold, G. Roberts, & S. M. Malcolm (Eds.), *This year in school science 1991: Technology for teaching and learning.* Washington, DC: American Association for the Advancement of Science (AAAS).

Linn, M. C., & Songer, N. B. (1993). How do students make sense of science? *Merrill-Palmer Quarterly, 39*(1), 47-73.

Linn, M.C. and Burbules, N.C. (1993) Construction of knowledge and group learning. In Tobin, K. (ed) *The practice of constructivism in science education*, pp.91-119. Washington, DC: American Association for the Advancement of Science (AAAS).

Linn, M. C., diSessa, A., Pea, R. D., & Songer, N. B. (1994). Can research on science learning and instruction inform standards for science education? *Journal of Science Education and Technology, 3*(1), 7-15.

Linn, M. C. (1995). Designing computer learning environments for engineering and computer Science: the scaffolded knowledge integration framework, *Journal of Science Education and Technology*, 4(2):103-126

Madhok, J. J. (1992). *The effect of gender composition on group interaction.* Paper presented at the Locating Power: Proceedings of the Second Berkeley Women and Language Conference, vol. 2, 371-85, Berkeley, California.

Matheson, K. (1991) Social cues in computer-mediated negotiations: gender makes a difference. *Computers in Human Behaviour, 7*(3), 137-45.

Minstrell, J. (1990). Facets of Students’ Knowledge and Relevant Instruction. Unpublished manuscript.

Minstrell, J. M., & Stimpson, V. (1995). A classroom environment for learning: guiding students' reconstruction of understanding and reasoning. In R. Glaser & L. Schauble (Eds.), *The Contributions of Instructional Innovation to Understanding Learning.* Mahwah, New Jersey: Lawrence Erlbaum Associates.

Morse, L., & Handley, H. (1985). Listening to adolescents: gender differences in science classroom interaction. In L. Wilkenson & C. Marrett (Eds.), *Gender Influences in Classroom Interaction*, (pp. 37-56). Orlando, FL: Academic Press.

Newman, D., Griffin, P., & Cole, M. (1989). *The construction zone: working for cognitive change in school*. New York: Cambridge University Press.

Pea, R., & Gomez, L. (1992). Distributed multimedia learning environments: Why and How? *Interactive Learning Environments, 2*(2), 73-109.

Perin, C. (1991). Electronic Social Fields in Bureaucracies. *Communications of the ACM, 34*(12), 75-82.

Philipsen, G. (1993). The Invention of Discussion. Paper presented at the SESAME Colloquium, Graduate Group in Science and Mathematics Education, University of California at Berkeley.

Pitkow, J. E., & Recker, M. (1994). Using the Web as a survey tool: results from the Second WWW User Survey. *Journal of Computer Networks and ISDN systems, 27*(6).

Pontecorvo, C. (1993). Social Interaction in the Acquisition of Knowledge. *Educational Psychology Review, 5*(3), 293-31.

Quittner, J. (1994) Johnny Manhattan meets the Furry Muckers. Wired Magazine, 2 (3), pp. 92-97, 138

Resnick, L. B., Salmon, M., Zeitz, C. M., Wathen, S. H., & Holowchak, M. (1993). Reasoning in Conversation. *Cognition and Instruction, 11*(3 & 4), 347-364.

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

Rogers, E.M.; Collins-Jarvis, L.; Schmitz, J. The PEN project in Santa Monica: interactive communication, equality, and political action. *Journal of the American Society for Information Science, 45*(6):401-10.

Roschelle, J. (1992). Learning by collaborating: Convergent conceptual change. *Journal of the Learning Sciences, 2*(3), 235-276.

Sadker, M., & Sadker, D. M. (1994). *Failing at fairness: How America's schools cheat girls*. New York: Scribner & Sons.

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*, 37-68.

Schank, R. C., & Cleary, C. (1995). *Engines for Education*. Hillsdale, NJ: Erlbaum.

Shneiderman, B. (1992) Engagement and Construction: Education for the Post-TV Era. In Tomek, Ivan (Ed.) Computer Assisted Learning, Proceedings of the International Conference on Computers and Learning. June 17-20, 1992. Wolfville, Nova Scotia, Canada. Published by Springer-Verlag, pp. 39-45.

Songer, N. B. (1993). Learning science with a child-focused resource: A case study of Kids as Global Scientists. In *Proceedings of the Fifteenth Annual Meeting of the Cognitive Science Society*.

Strike, K. A., & Posner, G. J. (1985). A conceptual change views of learning and understanding. In L. H. T. West & A. L. Pines (Eds.), *Cognitive Structure and Conceptual Change*. New York: Academic Press.

Strike, K. A., & Posner, G. J. (1992). A revisionist theory of conceptual change. In R. A. Duschl & R. J. Hamilton (Eds.), *Philosophy of Science, Cognitive Psychology, and Educational Theory and Practice,* (pp. 147-197) Albany, New York: State University of New York Press.

Tannen, D. (1994). *Talking from 9 to 5: Women and men in the workplace: language, sex and power*. New York: Avon Books.

Tobin, K., & Garnett, P. (1987). Gender related differences in science activities. *Science Education*, *71*(1), 91-103.