A Culture of Understanding: An Examination of Face-To-Face and Computer Mediated Environments

Andrew Cohen

Learning Technology Center, Vanderbilt University, Box 45, Peabody, Nashville, TN 37203-0045

(615)-329-8905 E-mail: cohenal@ctrvax.vanderbilt.edu

Abstract: Schools should foster *cultures of understanding*, that is, student communities that actively inquire and intentionally build common knowledge structures. This paper analyzed the affordances of the Computer-Supported Intentional Learning Environment (CSILE) (Scardamalia, Bereiter, McLean, Swallow, & Woodruff, 1989), as compared to face-to-face collaboration for supporting cultures of understanding. The investigation was an analysis of twelve weeks of work involving thirty students in ten triads. The students were working on a unit, "Gravity and the Solar System". Part of this unit was devoted to students designing experiments and testing their hypotheses on two problems: "What affects how things fall" and "What affects the path of satellites/comets." Students' oral discourse from the CSILE and the face-to-face conditions were analyzed from video tape-recordings and transcripts. The results indicated that with respect to active monitoring and regulation of their own or others actions and ideas, hereafter called meta-processes, there was significantly more meta-processes in the CSILE condition compared to the face-to-face condition. The discussion focused on how CSILE supports meta-processes through interactions between students' work on CSILE, and oral inquiry about that work. The affordances of CSILE were discussed in light of other uses of technology in the classroom.

1. Introduction

Exposure to a scientific culture is beneficial for students in preparing them for productive life in an information-age society. A great investment in time and energy has been made to design learning environments where students can acquire both the factual knowledge and higher-order thinking skills. Yet there are well-known gaps in science learning. What kinds of improvements are likely to be most effective? Consider two approaches.

In a technologically advanced North American classroom, a session in which grade-six science students are studying gravity would likely use some type of computer technology to simulate laboratory experiments (e.g., Howe, 1990). Here, small groups of students gather about one computer running a science microworld. Students attempt to construct their understanding of concepts directly from their interactions with and about the simulation.

Evidence from this research suggests that the collaboration (1) helps make all students' ideas available to others for discussion; this helps all students to make contributions, and facilitates students' monitoring and regulation of their own and others' ideas (Palincsar & Brown, 1984); (2) fosters progressive scientific discussion among students about what will happen (e.g., Howe, 1990); and (3) promotes conceptual change and improved understanding when the small groups comprise students with differing pre-conceptions or ideas about the concepts represented (e.g., Howe, 1990). However, two problems remain: (a) students' investigations are often centered about outcomes rather than a systematic effort to understand concepts (Schauble, Klopfer, & Raghavan, 1991); (b) students often have similar pre-conceptions about a phenomenon, which makes it less likely that they will be able to use these to advance their understanding.

In an effort to promote a more scientific structure in students' investigations and conversations about simulations, some researchers have attempted to provide a structure which requires students to collaboratively plan experiments, predict outcomes, reconcile outcomes with predictions, and form conclusions (e.g., Linn & Burbules, 1993). This kind of a structure has been shown to improve students' integration of data with their theories, facilitating more general, scientific understanding. These environments combine microworlds and a scientific structure to facilitate face-to-face collaboration. For the rest of this paper I will refer to this framework as the *face-to-face* condition.

However, Scardamalia and Bereiter (1994) argue that more needs to be done to focus students' attention on their own ideas -- in particular their theories and predictions -- instead of concentrating exclusively on the concepts and features of the simulation itself. Their goal is to set up a dialectic between concepts presented in the simulation and students' interpretations and representations of those concepts. It is through this dialectic, they argue, that knowledge advances take place. Computer-Supported Intentional Learning Environment (CSILE) (Scardamalia, Bereiter, McLean, Swallow, & Woodruff, 1989), a communal database system, is designed to support this dialectic. It integrates technology into the classroom so as to support collaborative inquiry with and about students' ideas and simulation concepts, aiming to maximize the affordances of both written and oral discourse.

In a classroom where CSILE is being used in conjunction with computer simulations, students can engage in several activities different from those described in the face-to-face condition: (1) Students contribute individual as well as collaborative ideas in the form of written theories, new information, comments, plans for experiments, predictions about outcomes, and conclusions; these ideas become not only visible to all members of a group, but permanent and retrievable objects; (2) students pursue individual as well as collaborative experiments; and (3) the communal database allows students shared access to their own and others' experiments and ideas, including plans, predictions and conclusions. These activities theoretically should facilitate meta-processes, or students' monitoring and regulation of their own and others' actions and ideas. This environment, which will be called the *CSILE condition*, combines face-to-face and CSILE-mediated collaborative inquiry.

The main goal of the present research is to investigate collaborative processes as supported by the distinctive features -- hereafter 'affordances' (Gibson, 1977) -- of CSILE as compared to more exclusively face-to-face cultures. The characteristics of CSILE are not in any sense opposite to those of face-to-face environments; rather CSILE supplements face-to-face environments. In this paper, CSILE and face-to-face conditions are to be compared in their support for meta-processes. Specifically, the present research addresses the following question: As measured in students oral discourse, does a CSILE condition support more meta-processes than a face-to-face condition? Based on such an examination, this project was designed to provide a detailed account of the cognitive and interpersonal processes occurring in each condition.

2. Method

2.1 Subjects

Thirty students of one intact grade-five/six elementary classroom participated in this study. The students were from a middle-class, urban, elementary school. The class was part of the ongoing CSILE research program. Students varied in their experience with CSILE, over 50% having almost one school-year of experience, the rest having either two years' or three years' exposure.

The teacher in this study had been with the CSILE project since 1987, and was familiar with the research proposed and with the researcher. He volunteered to participate. He had taught a unit titled "Gravity and the Solar System" on numerous occasions.

2.2 Materials

The computer network consisted of eight networked Macintosh II computers, and one server, a Macintosh Quadra. CSILE, a client-server collaborative database system was running on all eight computers in the classroom. A modification was designed to facilitate students' experimenting. It allowed students to add, as one entry, the following sub-sections: 'What they were trying to find out', their 'Plan', their 'Prediction', and 'What they learned'. These entries in CSILE will hereafter be called *electronic proformas.* In the face-to-face condition, students had a folder of pencil and paper proformas, forms on which students could record the same information as the students in the CSILE condition. For the rest of this paper this form will be referred to as the *pencil-and-paper proforma*. Computer simulations, *microworlds* for each problem, were developed by the researcher using the simulation package, Interactive Physics™.

2.3 The Experimental Setting

For the CSILE condition, the students had their own computers on the network described above. The computers were all running the physics-simulation environment and CSILE. The students were seated next to each other. For the face-to-face session, all students gathered about one Macintosh running the physics simulation template but not running CSILE and had a folder of the pencil-and-paper proformas.

2.4 Design

The experimental design provides a basis for a comparison of CSILE and face-to-face cultures, two realistic classroom conditions. For the comparison of conditions, the design is an incomplete between/within design with two factors, CSILE/face-to-face, and type of problem, "What affects how things fall" and What affects the path of satellites/comets". This design allows us to investigate the affordances of a CSILE culture as compared with a face-to-face culture for supporting meta-processes.

2.5 Procedure

2.5.1 Assignment to Groups and Training

The students worked in groups of three, and there was a total of ten groups ("triads"). The students self-selected group members with minor adjustments from their teacher. Group membership was fixed over the course of the investigation. The ten triads were stratified and randomly assigned to the two conditions.

All the students were introduced to simulations and procedures by the researcher and the teacher for the physics problem "What affects the time of the swing of the pendulum'. Each group had two training session in using the simulation, setting variables, reading times and resetting the simulation, one with CSILE and one with face-to-face, each session lasting between 35 to 45 minutes.

2.5.2 CSILE and Face-to-face Conditions

For the experimental CSILE condition, the students has access to the relevant microworld and worked over three sessions. Each session lasted between 35 and 45 minutes. The students used CSILE to record, store and retrieve all their work. For the first two sessions, the students started each session with one, consensual, high-level goal. Subsequently they each planned, made predictions, executed experiments and explained what they had learned. Experiments were conducted using the microworlds described above. The students could work alone or collaboratively. Each of the first two sessions ended with students developing one consensual conclusion. The third session was the same, but at the end the students completed a consensual conclusion and synthesis of all three sessions. In the CSILE condition, students individually and/or collaboratively articulated (and entered into CSILE) what they were trying to find out, their plan and their prediction. They did so on their own computer, sitting near their collaborators. Oral exchanges were frequent and central to completing the problem. The teacher was available to answer conceptual (physics) questions in both conditions. All sessions were both video- and audio-taped by the researcher.

2.5.3 Face-to-face Condition

In the face-to-face condition, the same procedure was followed with the following exceptions: the students used the pencil-and-paper proforma to record, store and retrieve all work, and the students jointly ran experiments and entered the above information into the folder of proformas.

2.6 Data and Measures

The data came from the transcribed oral discourse of the students while they were doing their experiments in CSILE and the face-to-face conditions. In order to score the oral discourse, several initial steps had to be taken. The transcript had to be parsed according to the type of operation in which the students were involved, the size of unit of discourse to be analyzed, and finally the discourse had to be analyzed.

2.6.1 Unit of Analysis

A simplified notion of exchange structure was used. An *exchange* was defined as an initiation plus all the utterances following until another initiation occurs. Inter-rater agreement was over 83% for two, independent raters on over 25% of the dataset, randomly selected to assess reliability.

2.6.2 Scoring the Oral Discourse

Each oral exchange was categorized as (1) meta-process orientation: Executive and regulatory, reflective or metaprocedural processes, (2) problem-centered orientation: Problem-centered knowledge, including procedure related to data or theory, (3) referent-centered orientation: Referent-centered knowledge or outcome-oriented statements, and, (4) other: No knowledge and general procedure. Inter-rater agreement was over 87% for two, independent raters on over 25% of the dataset, randomly selected to assess reliability.

2.6.3 Student Roles in Oral Discourse: Analyzing Students' Meta- Processes

To further the analysis of meta-process, the oral discourse exchanges which were scored as meta-process oriented were broken down into three categories: monitoring internal (MI), the self monitoring as opposed to monitoring others' ideas, coordinating others (CO), coordinating others' actions or ideas, and monitoring external (ME), monitoring others' actions or ideas. Inter-rater agreement was over 89% for two, independent raters on over 25% of the dataset, randomly selected to assess reliability.

3. Results

This section compares the *oral discourse* of the students in the face-to-face condition to the *oral discourse* of the students in the CSILE condition. For this analysis, the score was the proportion of meta-process exchanges for each group. A comparison of means using a paired t test revealed that in the CSILE condition as compared to the face-to-face condition, there were more exchanges scored as meta-process oriented. The difference between conditions was significant $t(7)=2.36$, $p.<0.003$ (see Figure 1).

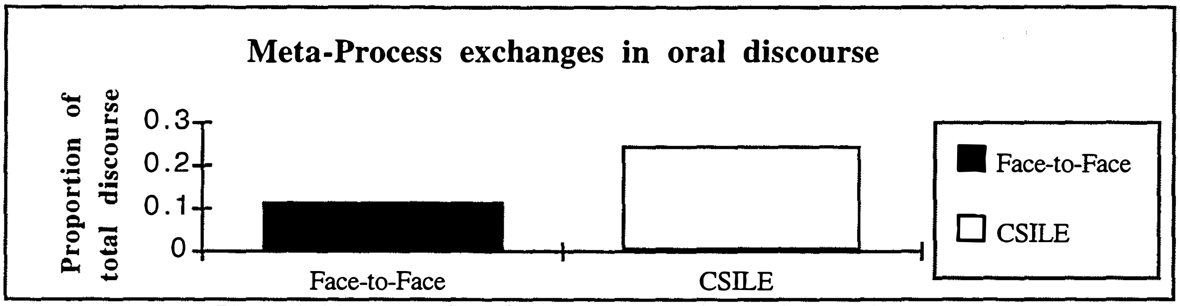

Figure 1: The proportion of meta-process exchanges in oral discourse.

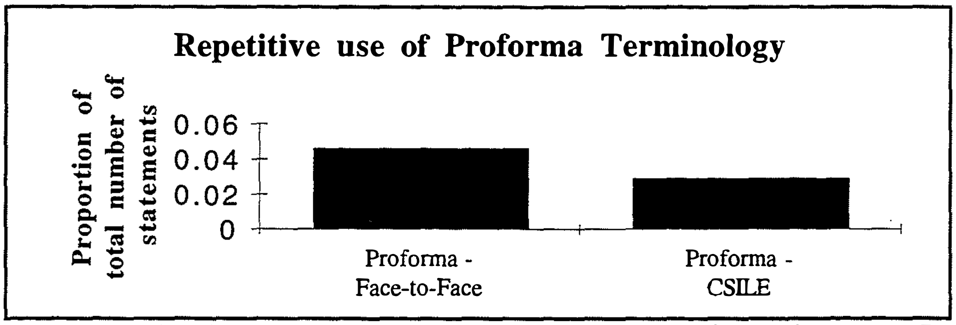

Figure 2: The proportion of proforma terminology in oral discourse across the face-to-face and CSILE conditions.

These data indicate a correlation between an increase in meta-processes and decrease in use of proforma terminology. It is argued that in the face-to-face condition, the students use the proforma structure as the focus of their discourse, while in the CSILE condition, because each section of the proforma need not be negotiated, the proforma becomes a background tool facilitating a deeper focus on students' ideas.

To examine the differences in the types of meta-process oriented exchanges in the CSILE as opposed to the face-to-face condition, the types of meta-process oriented exchanges were divided into three categories, monitoring self or group ideas as opposed to others' ideas (MI), coordinating others' actions or ideas (CO), and monitoring others ideas or actions (ME). The score was the proportion of exchanges for each group scored as MI, CO or ME. The analysis showed that there were similar amounts of monitoring internal (MI) in both conditions, and little coordinating of others (CO) in either condition. However, there were significantly more events where one member of the group monitored another's ideas or actions (ME) in the CSILE as compared to the face-to-face condition $t(7)=77.2$, $p.< 0.01$ (see Figure 3).

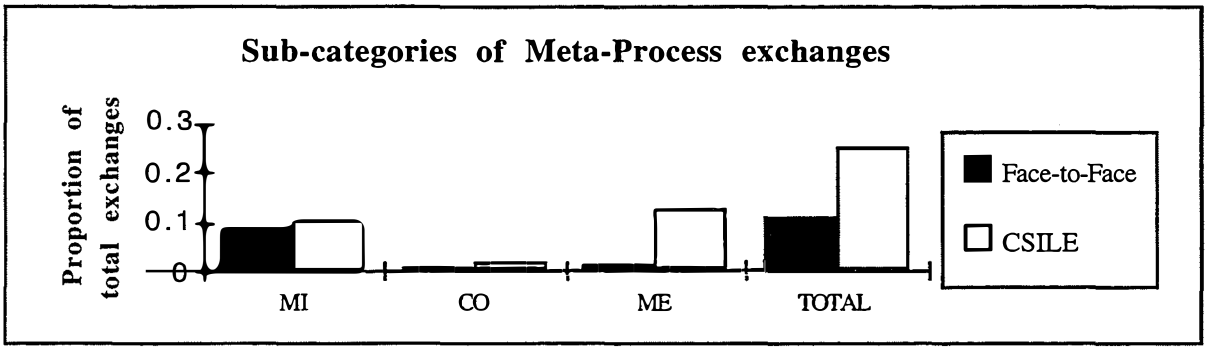

Figure 3: The proportion of meta-process oral discourse viewed by sub-category.

Of additional interest was who was doing the monitoring. In order to assess this issue, for each student the total number of contributions to exchanges in each on the roles (*meta-process, problem-centered, referent-centered*, and *Other [see method section]*) was summed and divided by the sum of all such contributions for the group as a whole. This proportion represented the students *total oral discourse contribution score*. Students were assigned to high-, medium-, and low-contributor categories based on the proportion of total contribution within their group. A similar score was calculated for monitoring, where for each student, the number of monitoring others' *roles* was summed and divided by the total number of *roles* for the group. This proportion represented the student's total Monitoring External (ME) score. Each student was assigned to high-, medium-, or low-monitoring categories based on this proportion. An analysis revealed a correlation between the category of monitoring and the total oral discourse, r=0.625, df=24, $p<0.001$. This analysis indicates that high-contributors are the most likely to monitor others' work whereas low-contributors are more likely to be monitored by others, at least through oral discourse. Thus, in the CSILE condition the high-contributors tended to focus their attention on others' ideas rather than on just their own.

In summary, there is a higher proportion of meta-process oriented exchanges and a lower proportion of proforma-statements in the CSILE condition than there is in the face-to-face condition. Additionally, an investigation of monitoring activities, indicates that students are more likely to monitor others' ideas and experiments when using CSILE. In the face-to-face condition, they only monitor their own ideas and past work. In particular, in the CSILE condition, it is the high-contributors that focus their attention on others' work, rather than only on their own ideas.

4. Discussion

The present research has shown that students can take over powerful processes in learning and the creation of knowledge. The major implication of this study is about how technology is used in creating cultures of understanding. CSILE projects, including the present one, have begun using technology in a novel way, affording students the possibility of rich interaction between written and oral discourse. As the results of the present study suggest, such interaction facilitates meta-processes at a higher level than that for students in just face-to-face collaboration. To date, teachers and researchers have rarely used technology to afford these types of processes. In general, technology appears to be employed as a tool to build representations for collaborative inquiry which would otherwise be difficult or impossible to build, or as a tool to create better final products and presentations.

As designers of new and novel technologies, investigators of Cognition and Human Computer Interaction share a responsibility not simply to use technology to amplify what we already can do or what we already know, but to afford new possibilities for the growth of knowledge both within ourselves and for our society. CSILE is one of these technologies, and this study indicates that students in a CSILE culture are able to engage in the types of high-level, distributed processes, specifically meta-processes, more commonly found in scientific research groups (Dunbar, 1993). As knowledge construction becomes communal, it becomes something more than what happens primarily in the head of the learner. In fostering intentional inquiry and collaborative production of knowledge in the social world, CSILE helps shift the focus of education from inward to outward, from the self to the self-in-the-social-world.

5. References

Dunbar, K. (1993). How scientists really reason: Scientific reasoning in real-world laboratories. In R. J. Sternberg & J. Davidson (Eds.), Mechanism of Insight Cambridge, MA.: MIT Press.

Gibson, J. J. (Ed.). (1977). The theory of affordance. Hillsdale, NJ: Erlbaum.

Howe, C. J. (1990). Explanatory concepts in physics: Towards a principled evaluation of teaching materials. Draft copy - Department of Psychology - University of Strathclyde.

Linn, M., & Burbules, N. (1993). Construction of knowledge and group learning. In K. Tobin (Ed.), The practice of constructivism in science education. Washington, D. C.: American Association for the Advancement of Science.

Palincsar, A. S., & Brown, A. (1984). Reciprocal teaching of comprehension-fostering and monitoring activities. Cognition and Instruction, 1(2), 117-175.

Scardamalia, M., & Bereiter, C. (1994). Schools as knowledge-building communities. In S. Strauss (Ed.), Human development: The Tel Aviv annual workshop: Vol. 7. Development and learning environments. Norwood, NJ: Ablex.

Scardamalia, M., Bereiter, C., McLean, R. S., Swallow, J., & Woodruff, E. (1989). Computer-Supported Intentional Learning Environments. Journal of Educational Computing Research, 5(1), 51-68.

Schauble, L., Klopfer, L. E., & Raghavan, K. (1991). Students' transition from an engineering model to a science model of experimentation. Journal of Research in Science Teaching, 28(9), 859-882.