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Exploring Collaborative Aspects of Knowledge Building Through Collaborative Summary Notes

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Abstract. We explore the use of collaborative summary notes in Knowledge Forum™ (KF) as a way to capture the distributed nature of knowledge advances among groups of students building knowledge together. The purpose of this exploration is to develop assessments that can be used for *scaffolding* the discourse and promoting ideas within the community, as well as for evaluation. The unit of analysis was the group on KF. Students in two high school classes collaborated on a progressive inquiry exploring aspects of a recent SARS outbreak and some related topics. They were asked to write collaborative, co-authored, summary notes to make the nature and importance of the knowledge advances they achieved clear for their peers. The findings indicate that note ratings were positively related to the number of co-authors and the number of views (different discussion spaces) in which students had worked.

Keywords: Knowledge building, assessment

INTRODUCTION

Theories informing CSCL (Computer Supported Collaborative Learning) posit learning as collaborative and distributive (Brown, Collins, & Duguid, 1989; Salomon, 1993; Stahl, 2002), and more emphasis is now placed on learning as participation in the practices of a culture (Roth & Tobin, 2002). Assessment practices have not kept pace with these developments (Shepard, 2001). Chan and van Aalst (2004) identified three problems with teacher-administered assessments. First, assessments need to capture both individual and collective aspects of learning. Second, there is a need for assessments to capture both the learning outcomes and the (collaborative) learning process. Third, there is a need for greater alignment of learning, assessment, and instruction. Currently, it is widely recognized that assessment is part of the instructional process and it plays a central role in *scaffolding* (i.e., guiding) student learning (Shepard, 2001). With the changing conceptions of learning emphasizing social and constructive nature of learning, there is a need to develop social-constructivist assessments that give students the responsibility to assess their collaborative processes and learning outcomes.

An example of an educational approach using a CSCL technology is ‘knowledge building’, defined as “the production and continual improvement of ideas of value to a community, through means that increase the likelihood that what the community accomplishes will be greater than the sum of individual contributions and part of broader cultural efforts” (Scardamalia & Bereiter, 2003, p. 1370). Knowledge building emphasizes that knowledge is the achievement of a community, and is improvable by means of discourse (Scardamalia, 2002). Although much of a knowledge building discourse takes place in face to face interactions, a CSCL environment is often used to support it and to provide a reliable trace of how ideas are developing. Students can use this trace to reflect on the community’s learning. The software most often used by proponents of Bereiter and Scardamalia’s version of knowledge building is Knowledge Forum™ (KF), which has some specific features designed to support *working with* knowledge. Some of these features are different ways to link notes (e.g., adding them as references to a new note), and *views*. A view refers to a space where notes are located, similar to a “conference” in other CSCL environments. Students can create new views when, for example, a need for a new discussion is emerging and they need a space for that discussion.

van Aalst, Chan, and Lee developed a portfolio-based approach to assess the *process* of knowledge building (Chan & van Aalst, 2003, 2004; Lee, Chan, & van Aalst, this volume). They introduced a small set of “pedagogical knowledge building principles” describing collective and individual aspects of knowledge building: (a) working at the cutting edge, (b) progressive problem solving, (c) collaborative effort, and (d) identifying high points of the discourse. For example, their principle ‘working at the cutting edge’ requires that students collectively raise significant problems, that is, problems that take the range of ideas within the community as well as the available authoritative sources of knowledge into account; it further requires that the community investigates at least some problems of this kind. Chan and van Aalst (2003) asked students to develop electronic portfolios in KF, using clusters of notes in the KF database as artifacts. This approach revealed some metacognitive benefits, as students realized that the need of developing these portfolios helped them understand how they could best align their work in KF with knowledge building theory. Whereas these studies examined distributed phenomena, the unit of analysis in the assessment was the *individual learner*. More research is needed to improve the coherence of the assessment task and the phenomenon that is being assessed: collective phenomena should also be assessed at a collective unit of analysis (Stahl, 2002).

A pedagogical problem highlighted by literature on knowledge building is that the completion of tasks takes center stage in school (Bereiter & Scardamalia, 1993; Hewitt, 2002). This does not mean that tasks are unimportant (see Collins, 2002, for a discussion), but that the tasks are more prominent in the students' thinking about what they are doing than the learning goals. Students are more likely to say that they are writing an essay than that they are trying to articulate lessons learned from their analysis of a problem, so that those lessons learned can find their way into the community's knowledge base. Although Hewitt analyzed the problem in terms of instructional design and teacher roles, assessments also contribute to the problem because assessment and instruction are "two sides of the same coin" (National Research Council, 1996; Shepard, 2001).

The goal of this study was to explore an assessment strategy designed to capture collective as well as individual aspects of knowledge building. Most of the analysis focuses on a collective unit of analysis—a group on KF. The students were asked to write collaborative summary notes to make the nature and importance of what they learned clear for their peers. These notes were coauthored by all students in a group who were judged by the students to have made significant contributions to that learning. The task required that students reflected on the distributive nature of knowledge.

METHOD

Participants

The participants were students in a grade ten course on career preparation and research techniques (n = 21) that was part of a pre-IB (International Baccalaureate) program, and a grade eleven course on computers and their impact on a "global society" (n = 19), both taught by the same teacher at an inner city school in a metropolitan center in Western Canada. Some of the students (approximately 40%) were familiar with KF. However, the students did not have prior experience conducting an extended collaborative inquiry.

The teacher

The teacher (the second author) had ten years of experience teaching mathematics and computer studies in middle and high school. He completed a masters degree focusing on cognitive strategy instruction in 2002 and was in his third year of teaching with KF. Prior to starting with KF in 2001, he attended a four-day workshop on knowledge building led by Scardamalia and colleagues. The teacher gradually attempted to integrate knowledge building more fully into his teaching. In the first year he taught grade eight mathematics and posted weekly "challenge problems." His belief that students needed considerable skill development (factoring, solving equations, etc.) to prepare for the next grade was an obstacle in attempting a more discourse oriented approach to mathematics teaching (e.g., Lampert, Rittenhouse, & Crumbough, 1996). The next year, he taught a grade nine course on personal development and research techniques that offered more flexibility. However, in this course he also felt that students first needed to develop research skills before attempting knowledge building and he had relatively little time available for knowledge building. The teacher's approaches up to this point reflect an often held expectation that students need to develop foundational skills *before* they can successfully engage in knowledge building, rather than developing those skills in the context of student-directed inquiry. In the year of this study, the teacher was ready for a more extensive implementation of knowledge building and agreed to a two-month student project starting within a few weeks of starting the course (i.e., without taking time for foundational skill development).

Procedures

At the beginning of the school year the teacher and researcher met several times to discuss how to make the pedagogical knowledge building principles (Chan & van Aalst, 2003) more central to the class's work, as well as the role and nature of the final products the students should produce. A two-month unit was then designed in which students could investigate some problems then of interest to Canadians—SARS, Avian Flu, and computer viruses. These topics were current, and had a loose connection to the curriculum: research for the grade ten class, and the use of a CSCL environment for the grade eleven class. The two classes shared a KF database and worked on the same topics; the students were divided into four groups with an equal number of students from each grade in each group. Each group had its own virtual workspace in KF and was not required to interact with the other groups. Both classes had daily access to a computer lab during class time. A three-phase inquiry model was used to provide some structure to students by which they could manage their inquiry (van Aalst, 1999). This was considered necessary because both the teacher and students had limited experience with extended collaborative student projects. The three phases of the project are described below.

Phase one(two weeks): The students read widely in this general area, using internet resources as well as paper resources. The goal here was to enable students to identify some problems that they could investigate (Polman, 2000). The students were then encouraged to prioritize a few of these problems and to develop brief proposals. The goal of this process was to ensure that each group had promising ideas for inquiry, as well as adequate resources. The end of phase one resulted in collaboratively written proposals (in KF). To do prepare these proposals, students first developed a process for prioritizing the problems that had emerged, as the students in each group came form both classes and did not all meet face to face.

Phase two (four weeks): The students researched their problems collaboratively, reading information on the internet and from other sources. The students were encouraged to evaluate the likely credibility of the sources (i.e., a web site by the World Health Organization could be more trustworthy than one by a person not declaring his/her credentials), and to examine the evidence for the claims made in the sources. Some papers from professional journals were introduced by the researcher to improve the collection of trustworthy sources students were using.

Phase three (two weeks): Collaborative Summary Notes were introduced as a way to articulate what the group had learned about each problem it had investigated and on which it felt it had made some progress. These notes followed a scientific genre in which students (a) stated the problem on which they were reporting; (b) explained the background of the problem, linking to their work in phase 1 in which they identified problems; (c) described what they did to investigate the problem and reported the main findings; and (d) explained the significance of the findings as well as their limitations. The instructions to students, provided by the researcher, stated: "Each note should report what the class has learned about a specific question. Do not write notes about questions that you think you did not learn much about. … Overall, there may need to be perhaps 20 to 30 notes, but it may also be considerably less." These instructions also pointed out that a specific student could be a co-author of several collaborative summary notes.

Data sources, measures, and analyses

The following data were collected:

Server log data: To provide a general description of the KF database, the Analytic Toolkit for KF (Burtis, 1998) was used to examine the following variables: number of notes written, number of notes that were linked to other notes, number of views worked in, and percentage of notes in the database that a student had read. According to Burtis, these data are basic indicators of knowledge building. Students are expected to make connections between ideas, which is typically represented by a high percentage of notes that are linked to other notes.

Ratings of collaborative Summary Notes: The collaborative summary notes were evaluated with the rubric shown in Table 1. This rubric was provided to the students by the researcher and follows a style similar to other rubrics used by the students at this school. All the summary notes were scored independently by the researcher and a research assistant specializing in educational technology, leading to an inter-rater agreement of 82%.

Table 1
Rubric for Assessing Collaborative Summary Notes

Criterion	D	C	B	A
Structure	At least two components of the note are superficial or missing (1)	At least one component of the note is superficial or missing (2)	All parts are complete, but the note may be longer than necessary and lacks focus (3)	All parts are complete and reasonably succinct (4)
Co-authors	Not done (1)	Significant omissions in the author list, or it is just a list of friends (2)	Most students who contributed to the ideas and work are co-authors; there may be some students who made only minimal contributions. (3)	All students who contributed to the ideas and work are co-authors, but no students who made only minimal contributions are coauthors (4)
Findings; significance	Significant errors in the reported findings; importance of findings is not pointed out (2)	Some reported findings are incorrect; the reported importance of the findings is questionable (4)	Findings are factual; the importance is explained clearly, but some limitations are not pointed out (6)	Findings are factual; the importance and limitations are clearly explained (8)

RESULTS

ATK indices

The two classes collectively wrote 491 notes (not including the collaborative summary notes). To examine if there were differences in participation levels in KF, as measured by the ATK indices, a Group on KF by Grade MANOVA of the three ATK indices was performed. The findings indicated that there were no statistically significant main effects. However, there was a significant Group by Grade interaction for Notes Written, $F(3, 32) = 5.19$, $p = .005$, $\eta^2 = .33$. Further analysis revealed that this was because in group B, grade eleven students wrote considerably more notes than grade ten students (on average16, compared with 6). Table 2 shows means and standard deviations for notes created, the percentage of notes that were linked, and the percentage of notes read for the four groups on KF.

Table 2
Mean (SD) ATK Statistics for Four Groups on KF

	Group A	Group B	Group C	Group D
Notes Created	14.9 (4.7)	11.2 (6.4)	15.9 (5.3)	13.1 (3.3)
% Notes Linked	47.1 (18.0)	40.9 (18.5)	50.4 (15.3)	45.3 (17.3)
% Notes in database Read	30.5 (13.7)	31.7 (20.3)	18.6 (4.7)	20.0 (5.2)

These findings indicate that participation levels were somewhat higher than reported in other studies. For example, Hsi (1997) found that grade eight students wrote on average 4.82 notes over an 18-week period. However, the percentage of notes linked was lower than expected. In some other classrooms, this measure was in excess of 80%.

Initiating the inquiry

In phase one, the students did background reading and formulated research questions. Collectively, the students contributed 200 notes during this phase (40.7% of the database), reflecting that students spent considerable effort to articulate, refine and prioritize problems. Of the 200 notes, 55 notes (27.5%) were single notes, 89 notes (44.5%) were in 31 threads of 2-5 notes, and 56 notes (15.5%) were in 7 threads of 6-10 notes. These thread lengths are commonly observed in online discussions (Hewitt, 2003). Within each group, between 42 and 50% of the notes were read.

The different groups each used approximately one-third of the notes in phase one to organize the task. (Not all students had face to face contact, as they were from two classes.) For example, "… We're a little concerned that not everyone will be gaining equal knowledge on these topics because some of us will not be as articulate or as good in research as the others. Also, we will be true 'experts' on only the subjects we researched on. It's important that everyone has a good idea about all of the subjects to be covered." (a group D student). Other notes reported information that students found, and further questions that emerged.

At the end of phase one, the students formulated research questions and voted on these to come up with a small number of questions that they could research further in phase two. For this the researcher provided sample notes which included the question, background, proposed procedures, and expected outcomes. Group D chose to focus on the following questions. 1) How does fear affect our outlook on viruses? 2) What is the most effective way to minimize the spread of Avian Flu? 3) What caused the recent outbreak in China? How did it return? Other groups focused on the economic impact of SARS and on avian flu. For example, group A asked "Why does the Avian Flu only transfer by being in close proximity to poultry and not through eggs or meat?" Group B asked "Why has the media blown the SARS incident into such a large media explosion? If they hadn't have, would it have become a larger problem?" The discourse leading up to the research questions merits deeper analysis than we can provide here, but from these examples it appears that all groups arrived at explanation-seeking questions (e.g., Lipponen & Hakkarainen, 1997).

Collaborative Summary Notes

The students submitted 32 collaborative summary notes describing their knowledge advances. The notes were evaluated using the rubric shown in Table 1; the rubric assessed the structure of the notes (4 points), the extent to which students correctly gave credit to the contributions of collaboration (4 points), and the reporting of the findings (8 points). The total of these scores was divided by four to obtain a note score between 0 and 4. We first present one sample summary note and analyze its features in terms of the rubric, and then report the note ratings for all summary notes. Ten of the 32 summary notes can be viewed on the internet in a virtual tour (www.educ.sfu.ca/kb/KF_Databases/KF_Databases.htm, last visited February 28, 2005).

Sample summary note

The note shown in Figure 1 was written by a grade 10 student, and was co-authored by two other grade 10 students and three grade 11 students.

> ***Research Question*** What is the economic impact of small-scale or large-scale quarantine? How much are we willing to damage the economies of affecting countries to ensure that Avian flu doesn't spread? How much is it costing the government to have birds tested, in relation to how much it's costing poultry farmers to slaughter their chickens?
>
> ***Background*** Looking at the SARS outbreak that occurred last year, many countries and their economies were affected. The tourism industry for many cities like Toronto experienced a major decrease in the number of tourists that were visiting. Everyone was scared and worried about getting infected. Now that the Avian Flu is spreading, again the fear of getting infected, or having your chicken get infected is everywhere. There have been outbreaks here in BC, close to home, so it is important and interesting to look at how this virus has impacted our economy, and how worse things might get.
>
> ***Method*** To find information, I read information from different websites. I mainly looked for news articles, or sites that belonged to the WHO or other organizations, because I think that these are reliable sources, and have good information about the Avian Flu and its consequences. I also read the notes posted by everyone in our group, and posted my own notes to share the information I found.
>
> ***Findings*** I found that the main country that has been affected by this virus is Thailand. It has seen a 13% drop in the number of international arrivals. Also, during the first three months of this year, the export value of poultry products in Thailand had a significant decrease (94%, and frozen products dropped 68%).
>
> Besides Thailand, Vietnam has also been affected and is expected to have a cost of $690 million for the culling of poultry. An outbreak in Hong Kong will cost over $10 million (US), and the outbreak here in the Fraser Valley could cost about $3 million a week. This shows that the Avian Flu is causing damage to the world's economy, even though it might not be as bad as SARS. It wasn't expected that Avian Flu would have such a great impact, and some experts are saying that the costs aren't too bad in some areas, when compared to SARS.
>
> ***Importance of Findings*** So, by looking at the economic impact of Avian Flu, we can see how something small, and maybe not very important can become a very big problem. This virus began in birds, but has spread to humans as well. This spread is creating fear among everyone. Also, starting in Asia, this virus has spread over the globe. So many chickens are being killed, farmers are losing their businesses, and this is creating a huge loss of money. Earlier it was expected that the Avian Flu wouldn't have such a great impact, and would be lower than SARS. Maybe the amount isn't as great as it was for SARS, but it shows how something small can spread and get bigger, and could lead to a great loss.

Figure 1
Sample Collaborative Summary Note

This note received an overall rating of 2.5 out of 4.0, and was ranked 19 out of 32 (1 being the highest score). All of the sections were present, but some sections could have been done better. example, the background section could have provided links to specific notes the group had written as part of the work it had done to develop the research questions. The note received 3 out of 4 for structure.

With regard to authorship, the note was co-authored by six students, which may be taken as a self-report of how the main author thought the learning was distributed over group members. In some places, the main author wrote in the first person ("To find information, I read information from different websites") suggesting that we are dealing with the main author's personal learning. There also could have been evidence for specific contributions made by co-authors, for example, by linking to notes written by them. Therefore, the note received 2 out of 4 for crediting co-authors. Many of the other summary notes were written in first person and lacked specific credit to co-authors, as was the case for this note. This suggests that although the notes may have reflected what the group had come to understand as a result of collaboration, the students needed more guidance and time to make the notes reflect that. It is likely that many of the notes were written on behalf of the author group by a single author.

The note reported some findings and explained what they contributed to the class's understanding of Avian Flu. However, the note does not accurately reflect what the group discussed and, by the teacher's observation, understood. Certainly, after nearly a month of research on these questions (after phase one) by six students we would expect to see more evidence for understanding. The note received 5 out of 8 for reporting findings and implications. The ability to capture what the group had learned was a problem with many of the notes.

Overall, we were very pleased with most of the notes, including this one. However, our analysis indicates that work could be done with the class to improve its understanding of and proficiency at some of the processes involved in creating a summary note. Coming late in the course, the students were rushed in completing the assignment. In future, students could write summary notes throughout various inquiry projects, and thereby have opportunities to improve them over time.

Quantitative analysis

Table 3 shows the scores for the different sections of the collaborative summary notes, as well as the overall scores.

Table 3
Evaluation of 32 Collaborative Summary Notes

	Min.	Max.	Mean	Std. Dev.
Note Structure	1	4	3.06	1.19
Co-authors Named	1	4	2.09	1.09
Findings and Implications	4	7	5.13	0.83
Note Score	1.50	3.50	2.57	0.61

Attention to the note structure was generally as expected (research question, background, method, findings, and importance of findings), although in some cases one or two sections were underdeveloped. For the properly naming of co-authors the mean score was 2.09 out of 4. Some notes listed students as co-authors but did not make clear what the contributions of the co-authors were. For example, the students could have cited notes by co-authors more often in the summary notes, or they could have described their contributions in words. The *Findings* and *Importance of Findings* sections were generally somewhat underdeveloped (mean score 5.13 out of 8). Some notes described the findings in general terms without going into the specifics of what the group had learned.

The 32 notes were divided into two levels with note scores below and above the median score. As Table 4 shows, group B wrote a relatively high number of notes with scores below the median (7 of its 9 notes) whereas group C wrote relatively few summary notes (5, compared with 9 for the other groups). Group A had the highest proportion of notes above the median. Although there were some between-group differences, no corresponding differences were found for grade level.

Table 4
Classification of Collaborative Summary Notes

		Group A	Group B	Group C	Group D	Total
Note rating	above median	6	2	3	4	15
	below median	3	7	2	5	17
Total		9	9	5	9	32

The notes were also examined for the impact of the number of co-authors (not the rating the notes received for this) on the overall note ratings. As Figure 2 shows, notes receiving scores below the mean tended to have fewer co-authors than notes with overall ratings above the median; a Mann-Whitney test showed this effect was statistically significant (Z = -2.97, p = .007).

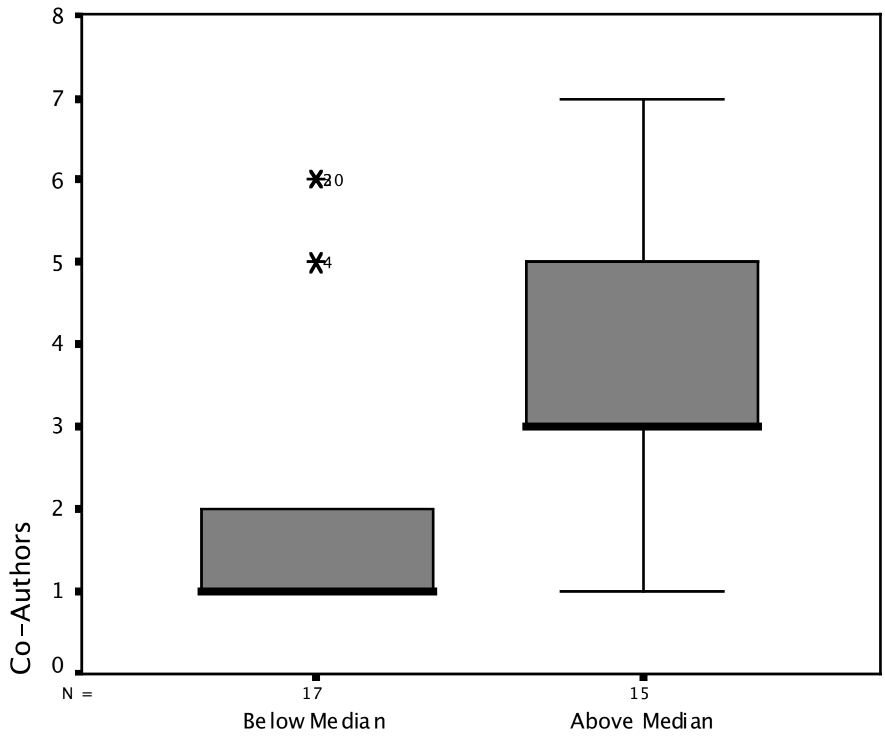

Figure 2
Number of co-authors with Note ratings below and above median

Exploring the collaborative summary notes as assessments

Summary Note scores

There are many ways to obtain measures of collective (i.e., group) and individual achievement, and we explore the following two:

Group Score: The sum of the scores for the summary notes by the group divided by the umber of students in the group.

Individual Score: The highest of the overall ratings of notes that the a student co-authored.

Table 5 shows the group scores, as well as the group averages and standard deviations of the individual scores. As one may expect, not every student co-authored at least one note: 17 grade ten students (81.0%) and 16 grade eleven students (84.2%) were co-authors of at least one summary note. In this study, the summary notes were not used for formal student evaluation; if they had been, the teacher would have worked with the students more to ensure that their contributions to KF would be counted towards their grade. Therefore, we report statistics only for students who co-authored at least one collaborative summary note.

Table 5
Group Score and Mean (SD) of Individual Score

	Group A	Group B	Group C	Group D
Students in Group	11	10	10	9
Co-authors in Group	10	8	7	8
Group Score	2.27	1.88	1.45	2.67
Mean Individual Score	3.20	2.34	3.14	3.19
SD of Individual Score	.39	.48	.38	.53

As Table 5 shows there were considerable variations in the group scores. The group scores are influenced by three factors. (1) The proportion of the students in the group who actually were co-authors of at least one note. This ranged from .70 for group C to .91 for group A, and is a measure of the extent to which learning is a distributive property of the group. If it is low, it suggests that some students were not represented by the summary notes. (2) The productivity of the group, the number of summary notes divided by the number of co-authors. Some groups may have learned more than other groups or took the assignment more seriously. In this study, this measure ranged from .72 (group C) to 1.125 (groups B and D). (3) The quality of the summary notes, as described by the rubric. These measures combine to form the group score as shown by the following formula:

$$GS = \sum_i \frac{n}{N} \times \frac{f_i}{n} \times NS_i$$

Here GS is the group score, n the number of co-authors, N the number of students in the group, f_i the frequency of note score NS_i, and the summation is over the different note scores for a group.

Regarding the *individual scores*, one may expect grade eleven students to outperform grade ten students because they are academically more advanced. However, a dependent samples t-test showed this was not the case, $t(31) = .545$, $p = .59$, two-tailed. A one-way ANOVA revealed a significant Group on KF effect, $F(3, 29) = 7.096$, $p = .001$, $\eta^2 = .42$; a post-hoc test (Tukey-Kramer) showed that the mean for group B was lower than the means for all the other groups, with no differences among groups A, C, and D.

Relationship between individual scores and ATK indices

Among the 32 students who co-authored at least one summary note, the individual scores were correlated with the number of views on which a student had worked, $r = .42$, $p = .017$. Regression analysis of the ATK data showed that Notes Created was the strongest predictor of Views Worked On, adjusted $R^2 = .24.$, $p = .01$. (This is usually considered a moderate association, see Abrami, Cholmsky, & Gordon, 2001.) Although previous research has revealed a relationship between Notes Created and measures of understanding (van Aalst, 1999), in this study there was no direct relationship between Notes Written and the individual note scores. What mattered more than writing notes was to create and work on multiple views. The creation of views is to some extent an *emergent property* of the discourse—students create views as needed by their inquiry; Bereiter (2002) has argued that emergence is an important feature of knowledge building (also see Sha and van Aalst, this volume). So, potentially the individual summary note scores capture an important aspect of knowledge building.

DISCUSSION AND IMPLICATIONS

In a well-functioning scholarly community, people are rarely begin a research project to produce a paper. Instead, they work on problems that interest them and that can advance the state of knowledge in a discipline (Bereiter & Scardamalia, 1993). When they feel they are making progress, they engage in a variety of tasks—including writing papers—to make that learning available to the discipline for debate, further testing, and application. In a scholarly community, *understanding* a problem is not enough. The understanding achieved must make impact on the state of knowledge in that field, and that means that people must work to promote their ideas. Yet, when we look at many implementations of CSCL technologies—KF included—the purpose of online discussion and "research" is to learn enough to write a paper that does not serve such a function. That is one reason why proponents of knowledge building often speak of the task-oriented nature of schooling (Hewitt, 2002; Bereiter & Scardamalia, 1993).

In this study we explored an assessment task that may help us do better. The premise of the task was that learning, is distributed, and that at least some assessment tasks should capture the distributed nature of achievement. The students were asked to prioritize problems on which they would work collaboratively and then wrote collaborative summary notes; they were asked to acknowledge the contributions of all students who contributed to the group's current understanding. In this study, the assessment task came at the end of the course, was designed by the researcher rather than the teacher, and was not part of the formal evaluation scheme. No doubt, the students saw it as "just another assignment." In future, the task needs to be designed by the class, and it needs to be embedded in knowledge building discourse (Scardamalia, 2002), so that the summary notes can be used to promote ideas. In this regard, the use of an inquiry model in which different inquiries had the same temporal scale (van Aalst, 1999) was constraining. In a real knowledge building community (e.g., a scientific community), new inquiries are beginning all the time, and different groups report their findings whenever they are ready to be reported. Thus, we need to think about a knowledge building community in a more fluid way than the inquiry model allowed. Then students write collaborative summary notes throughout the life of the community (once the community has had a chance to develop to some extent), and there are opportunities for gradual improvement of the practice of writing collaborative summary notes.

Our analysis of the summary notes identified several promising effects. First, more than 80% of the students made contributions to at least one summary note. That is an indicator of what Scardamalia (2002) calls the "democratization of knowledge," and it can be used to reflect on and improve the class discourse. Second, summary notes with more co-authors received higher ratings. This effect marks a possible benefit of collaboration, presumably through the diversity of the ideas and perspectives accounted for in the summary notes. However, for many notes this finding was based on *self-reports* and not on evidence identifying specific contributions to understanding by individual students. Third, the weakest aspects of the notes in terms of the ratings were summarization and making the importance of findings clear. This is not surprising as the students had little experience with the task, but it does suggest that cognitive strategy teaching (the teaching of framing questions, summarization, etc.) is necessary to improve this aspects of the notes. Nevertheless, we suggest that it is not necessary to deal with this issue *before* knowledge building, as had been the teacher's practice in the past. *Indeed, we propose that cognitive strategy instruction should be situated in the class's efforts to improve* *on the knowledge building discourse, as revealed by assessments of this kind.* Previously, we argued for a similar scaffolding function of assessment in the context of portfolios based on pedagogical knowledge building principles (Chan & van Aalst, 2003).

Most of our analyses used the group on KF as the unit of analysis, and some analyses revealed significant differences among these groups. Data from this assessment can therefore be used to interpret how the group is doing as a community. In this study, group membership remained fixed throughout the class's work, but that is not necessary. Groups can be assembled as needed by specific lines of inquiry that emerge in the class's work, and a group that works together for a short time can contribute one or more summary notes to the community discourse.

Students are individuals, and we cannot completely escape evaluating individual students. In this study, we went for simplicity and used the *best score* from all the summary notes a student co-authored to create an individual score. This is clearly a subjective choice, and other researchers and teachers may prefer to use central tendency measures such as the mean or median. The measure we used had a medium correlation with the number of views a student worked on. Although the number of notes created was a predictor of views worked in, it was not correlated with the individual scores. This finding is different from previous findings indicated that the number of notes created is a strong predictor of conceptual understanding (van Aalst, 1999). The current finding may reflect *emergent properties* of knowledge building, viz. that a group creates new views to accommodate the needs of the discourse.

We see the assessment task we have discussed as *prototypical*. Additional assessment tasks are needed that explore different ways of obtaining individual scores that can be used to scaffold and evaluate knowledge building. Additional research is also needed to examine relationships among the summary note scores and other assessments such as growth of domain knowledge and a range of trait variables. It also requires research to establish the findings reported above in settings where the assessment task is used for formal evaluation.

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