Heightening Reflection Through Dialogue: A Case for Electronic Journaling and Electronic Concept Mapping in Science Classes

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The literature on concept mapping and on journaling in the science classroom is well established (Ambron, 1991; Anderson & Huang, 1989; Barenholtz & Tamir, 1992; Emig, 1977; Fulwiler, 1980; Jegede, Alaiyemola, & Okebukola., 1990; Langer & Applebee, 1987; Nakhleh & Krajcik, 1991; Novak, Gowin, & Johansen, 1983; Novak & Gowin, 1984; Richardson, 1990; Wallace & Mintzes, 1990; Wandersee, 1990; Zulich & Bean, 1991), but there has been limited research on electronic variations of these well-established learning tools. Does the electronic medium alter the learning environment in significant ways? In valuable ways? In what ways might the electronic medium heighten "reflective practice," a quality promoted in teacher education (Bean & Zulich, 1989; Davison, King, & Kitchener, 1990; Schon, 1983, 1987; Zeichner & Liston, 1987)?

The literature on journals and concept maps is well established (in journals about general education, the science class, and preservice secondary science education). By this it is meant that there is a significant agreement in the literature about the value of journaling and concept mapping, not that the literature itself is beyond dispute, in terms of either research design or evidence. Nonetheless, the literature is persuasive less by its proof than by its purpose, by the articulation of clear purposes for both journaling and concept mapping. The primary rationale for journaling is that it should tip the responsibility for learning to the student and should encourage students to pose questions, to wonder, and, most of all, to make connections. As Emig (1977) and Fulwiler (1980) argued, journaling is tentative, exploratory, and allows students to think around the edges of issues. In journals, students are permitted to confront points of confusion, as well as articulate points of relative certainty. In addition, science students are invited not only to reflect on their learning but also to explicitly assess values and beliefs. This, in turn, discourages passivity, dependence, and rote thinking. Journaling is not the only medium that encourages students to make such connections, but it is a visible medium and permits students to revisit and revise their thinking process.

Likewise, the primary rationale for concept mapping is that students must establish connections between bits of given information, again in a visible medium. Concept mapping can stimulate students to demonstrate relationships among facts and concepts, demonstrate relationships between lower-order and higher-order concepts, and demonstrate relationships between old and new information within the students' own cognitive structures. It is noteworthy that writing of

any kind, not just journaling or concept mapping, makes many of the same demands and that the literature on cohesion in writing (Halliday & Hasan, 1976; Lovejoy & Lance, 1991) complements the literature on concept mapping. Concept maps, then, not only serve the same ends as writing (making connections) but also serve as a valuable means to writing (as a prewriting or planning tool) and as a valuable means for the teacher to assess learning-in-progress. While many people have used 'mapping,' 'webbing,' or 'clustering' as a general brainstorming device, Novak et al., (1983) were the first to justify and popularize it in science education. Of particular interest to science educators is the need to establish concepts in appropriate hierarchical relationship to each other. The electronic concept mapping used in 'Teaching Science in the Secondary School' adapted the concept mapping strategies developed by Novak and Gowin (1984) to a hypertext-like electronic medium.

The use of both electronic journaling and electronic concept mapping extends prewriting to a potentially more social medium and provides an opportunity to raise more questions from a Vygotskian perspective. For research purposes, the electronic journaling makes a permanent record of some of speech-like, social dynamics that are, arguably, prior to internalized thought. According to Vygotsky , as quoted by Wertsch (1985),

> It is necessary that everything internal in higher forms was external, that is, for others it was what it now is for oneself. Any higher mental function necessarily goes through an external stage in its development because it is initially a social function...(p.62)

Even if Vygotsky overstated the case that external, socially based dialogue necessarily precedes internal, higher-level reflection, we would agree that socially based dialogue *can* foster higher-level reflection.

Methodology: Naturalistic Study of a Preservice Science Course

The questions were explored by observing and interviewing 17 preservice science education students enrolled in a science methods course that used electronic journaling (Appendix A) and electronic concept mapping (Figure 1).

The preliminary naturalistic study (Lincoln & Guba, 1985) led to the development of numerous hypotheses that will serve as the basis for more focused follow-up studies. Although these studies still need to be conducted, the initial report on the observation was that the two learning tools, concept mapping and journaling, tend to stimulate complementary but different kinds of thinking: journaling tends to stimulate more inquiry and discovery learning, while concept mapping tends to stimulate more clarification, justification, and reasoned thinking of 'already-discovered' concepts. The electronic medium, by heightening the social interaction possible, tends to blur these distinctions. That is, by facilitating greater access to each other's writing, the electronic medium fosters greater dialogue, which in turn helps students to suspend premature closure and to rethink or re-explore certain concepts. This suggests that the medium (and the degree to which it fosters social interaction) is possibly as significant as the learning tool (concept mapping, journaling, brainstorming, experimenting'all of which can be done either individually or collaboratively). The electronic medium may provide a space in which some members of the learning community can participate in activities slightly beyond their competence, something called the 'zone of proximal development' by Lev Vygotsky. Although

the authors do not presume to prove or disprove Vygotsky's (1978, 1986) learning theory with this study, the observations permit questions to be asked about the nature of learning in general'and the interplay between individual and social thought.

The 17 students were enrolled in Teaching Science in the Secondary School, a methods course that requires students to explore such issues as inquiry learning, science literacy, classroom management, curriculum design, and perhaps most importantly, the nature of science. These issues were synthesized in a culminating article that represented the student's philosophy of science education. Although the course was 'writing-intensive' and involved considerable informal writing (journals, concept maps, reflection papers) and formal writing (the culminating paper), it also made use of many elements of a traditional science methods course: microteaching, lab experiments, and class discussion. Less traditional was the use of an electronic listserv and the use of electronically drawn concept maps. Students posted their journal entries twice a week to the listserv, so that, instead of being a private affair, their journaling became a conversation with 16 peers. Although students designed their concept maps on the computer (with a software package called *PIViT*: Brade, Krajcik, Soloway, Blumenfeld, & Marx, 1995) and revised them multiple times, students were not asked to paste their concept maps into the e-mail system or to share them in the same manner that the journal postings were shared. This, however, is something that is planned to try in a follow-up study.

No matter how much hard data collected in future studies, it is recognized that the analysis of student text, concept maps, and interviews only touches a small portion of the students' complex thought and requires inferences on the part of the researchers. The authors, therefore, suspect that the research is less conducive to producing well-supported answers than it is to eliciting thoughtful questions. Our readers are encouraged to take the questions, more than the tentative answers, into their own classes and research settings and to extend our reflective practice in new settings. Our readers are also encouraged to take forth a Vygotskian critique of individual reductionism or socio/cultural reductionism—that is, to question research that attempts to reduce learning to either purely psychological processes or to purely socio/cultural processes.

The data are both qualitative and quantitative. All names of individuals were changed to pseudonyms). The electronic journals (the posts on the class listserv) were archived, read, mapped, and loosely rated on a 'reflective judgment' scale (Appendix B and Appendix C); propositions were counted and categorized; and attributions (such as 'According to Ms. Driskoll, the teacher I'm aiding for') were counted and categorized according to levels of authority/evidence (Appendix D and Table 1). The propositions in the electronic concept maps were categorized and counted; the levels of hierarchy in the maps were counted (Table 2); and quantitative and qualitative changes in sequential maps were noted. In addition, students' exit interviews were videotaped, and the verbal content of the interviews were transcribed and analyzed. Finally, the culminating papers were read and evaluated for quality of conceptual development. Then these data were evaluated from several perspectives: the perspectives of a science educator and his doctoral student, the perspective of a writing program consultant, and the perspectives of the students themselves. By examining the students and their writings from multiple perspectives, there was a system in place called 'triangulation' to check each other's interpretations of qualitative data.

A few particular limitations of the study should be noted, even though we are not attempting to make universal claims as much as we are attempting to describe the particular experiences of a particular group of 16 students. One particular limitation is that the science educator and writing consultant believe in (and therefore might be predisposed to 'see') the benefits, not only of

technology, but also of a shift in attention from college teaching to college learning, from lecture to interaction, and from mass coverage to selective analysis of important concepts. Both of the innovative programs with which the researchers are identified, a technologically oriented college of education and a nationally recognized writing-across-the-curriculum program, have committed themselves to exploring the benefits of technology for learning and communication, even though neither program assumes that any given technological innovation is good for all things in all situations. Another limitation of the study was that the 17 preservice students (11 females, 6 males) enrolled in the course were all seniors (14) or post-baccalaureates (3) from fairly similar middle class backgrounds. Most would be engaging in their student-teaching experience in the next semester. Therefore, these students comprised a specialized population. (In subsequent semesters it was found that their senior status might be developmentally significant, that younger students are less likely to produce the kind of reflection observed.)

Findings and Discussion

Even though initially there were common purposes for using concept mapping and journaling, the 17 students observed had markedly different responses to them. Most enjoyed the electronic journaling to some degree, but not all found it valuable. Some found the concept mapping very valuable, while others would 'never use it again.' We sensed that students with the most fixed ideas (justifiably or not) tended to prefer concept mapping and tended 'to just think like that anyway,' as Jessica, Kate, and Peter independently reported. Students who were most receptive to others' ideas or who were least confident in their own thinking tended to favor the electronic journaling, as was the case for Mary and Aimee. Sam considered himself 'kind of intimidated by other people' and he simply felt more free to express himself 'to a computer screen than telling everyone face to face what I'm thinking.' Although students had strong personal and comfort zones, we suspect there are good reasons for nudging students out of their comfort zones. In Vygotskian terms, students were prevented from settling in either the 'intramental [mental] plane' or the 'intermental [social] plane' (Wertsch, 1997), and they were pushed into the 'zone of proximal development.' In other words, this Vygotskian 'zone' is neither just mental nor just social.

In some cases the students who preferred the concept mapping really were intellectually sophisticated (according to our intuitive judgement as well as measured by the reflective judgment scale ratings, concept map ratings, and range of evidence used to justify their claims; (Appendix E). Sometimes they had already privately debated the issues being openly debated in the electronic journaling. One woman described a very active reading process, in which she read, 'talked back' with annotations and marginalia, and imagined her own 'bubble maps.' By the time she had digested her reading, she really was ready to organize and shape her 'already-thought-out' ideas. In such instances, students were probably justified in finding the journaling 'a bit redundant' or 'not very informative. They were ready to hone the logical structure of their concepts and get on with it. For these students, the concept maps were what they 'sat down with to do' their papers. Nonetheless, these students became players in the intermental zone of less mature students, helping to mark the boundaries of the zone of proximal development, which Vygotsky defined as the distance between a student's "actual developmental level as determined by independent problem solving" and the higher level of 'potential development as determined through problem solving under adult guidance or in collaboration with more capable peers' (1978, p. 86).

Students who favored the concept maps generally found that 'the concept maps were very helpful

as far as organizing ideas' (Marsha) and that concept mapping pushed them to logically develop their ideas. As Sam said, "The lazy part of me would have stopped at three levels, but because we had to do five, I did." In hindsight, he appreciated this. Conversely, these students tended to be critical of the mishmash in the journals. Sam commented later, "It would have been nice to have a little more cohesion in the discussion. There were seventeen different ideas in there all the time and sometimes it was hard to sift through it.' He was particularly bothered by haphazard referencing or lack of citations altogether in the electronic journaling. 'Sometimes people would mention an article but not mention their author or anything like that. I think including a little more expert support would be a good idea.'

But in other cases, the students who preferred concept mapping were prematurely confident, had reached closure too soon, and had a low tolerance for change. These students tended to be trapped in what Vygotsky calls the 'intramental plane.' Kate, in many ways a strong student and logical thinker, was almost exclusively a deductive thinker. Kate struggled with inductive thinking, to the degree that she characterized inquiry labs as 'backwards': 'Like I was talking to [my professor] about that inquiry lab and thought I've never been taught to think backwards, you know. To me inquiry labs are backwards.' Kate was uncomfortable with induction, but we believe she needed the experience of induction, not only through the inquiry labs but, by degree, through the process of journaling.

Other students simply resisted change and were made somewhat uncomfortable by the sustained uncertainty and flux that characterized the electronic journaling. These students, too, needed to be nudged into more reflective practices. Furthermore, students who preferred concept mapping tended to resist the *in*efficiency of the journaling and the relative efficiency of the concept mapping. These students needed to realize that, while efficiency is to be valued, reductionism or simple-mindedness is not. Much critical thinking *is* inefficient. These students can benefit from being taught upfront that different conventions are valued in different modes of writing: the productive rambling valued in the electronic journaling will not be as highly valued as a tight, logical, cohesive presentation in the concept maps. The different modes of thinking and their accompanying forms of expression serve different purposes.

Some students clearly preferred the concept maps; others the electronic journals. However, when these students then interacted with each other on the electronic listserv, interesting things happened. While we do not want to describe the 'social plane' of learning too literally, the electronic listserv enhanced the visibility of some of the social threads inherent in any learning, even learning that is ordinarily assumed to be solitary. The source of questioning might be external, while the product of the questioning might be internal'or vice versa'and the electronic tools used in this class make the 'external' and 'internal' somewhat more observable. One student, for instance, concluded in an electronic post that 'it is not our job to teach values.' Another student then quoted the assertion and pitted it against another student's assertion, questioned the definition of value and whether 'encouraging acquisition of knowledge' isn't a value, and then suggested a broader definition of value. What tended to be 'fixed' in the concept maps were 'opened up' again in the journaling. Conversely, when someone seemed to wander way off track in the journaling, other students tried to 'fix' it. The interplay between open-ended inquiry and the more deductive, rational, tightly linked, concept maps is what characterized the best dynamics of the class.

Aimee was one who loved the journaling and had little use for concept mapping. Her electronic posts lacked organization; they rambled and seldom made a point. Instead, her posts led to a recognition of uncertainty and the articulation of a question which otherwise might not have been

asked. (Sometimes she asked questions herself; sometimes another student picked up the point of confusion and turned it into a question.) Then a student with 'an answer' might respond, perhaps one of the students who was uncomfortable with change or uncertainty. As an example, Aimee asserted in one post that 'science is not subjective or culturally laden,' that 'truth is in the eye of the beholder,' and that 'knowledge is changing.' In this one post she didn't seem to be aware of possible contradictions. Susan, who has co-authored biochemistry papers for professional journals, responded. Without labeling Aimee's ideas as contradictory, Susan identified and explained the way she had resolved the discrepancies. Susan became a player in Aimee's zone of proximal development, articulating a level of development beyond that which had been observed in Aimee's independent problem solving. According to Susan, 'I used to believe these were absolutes, facts,' she first conceded. She continued, 'But knowledge is forever changing, facts are later modified by corollaries.' Susan went on to distinguish between truth, which she believed to be somewhat stable, and knowledge, which she perceived as ever-changing and limited. Meanwhile, Aimee continued to enjoy the risk-free opportunity to 'think aloud.'

One of the benefits of 'thinking aloud' is an exploration of a free range of topics. The topics explored in the journaling tended to be of a wider and more personal range than those categorized in the concept maps, as illustrated in Table 2.

Depending on the quality of the 'answer' posted, other things happened. Still other students might question the source for a particular idea or might challenge an implication. As students quoted each other, they tended to do a superficial job of paraphrasing and sometimes blatantly misrepresented each other. This process (similar to the child's game of 'telephone') tended to heighten all students' awareness of the fragility of citations, the potential for misunderstanding, and the awareness that 'information' comes from somewhere, trustworthy or not. As Kate noted, 'One thing I did discover in the electronic journals...is that I would write an idea out and someone responds to my idea and they would rephrase my comment differently.' She then applied this insight to teaching: 'The way I present ideas as a teacher is going to be interpreted differently by every single student.' Although Kate did not extend her observations to Vygotskian learning theory, she could have, for she started to articulate the social dynamics underlying learning and the layering of 'who said so' in the construction of knowledge.

Students expressed strong preferences in their interviews for one medium or the other, but, regardless of their stated preferences, we argue that students do benefit from having to experiment with several different media, not only to develop two kinds of learning (inquiry learning through journaling and rational-organized thinking through concept mapping), but also to respond in various keys to each other. One student recognized a learning sequence, 'The electronic journaling helped the concept maps,' and others volunteered that 'the concept maps helped the paper.' To trace any one student's thinking, it would be necessary to loop through all three media and other students' questions, comments, and feedback, back to the student's thinking and out again. The electronic journal became an academic, socially constructed conversation to which all students contributed, questioning, quoting, analyzing, synthesizing, and questioning again. Contributing to the students' expanded zone of proximal development was not only the interplay between more and less mature thinkers, but also the interplay between more and less abstract/decontextualized forms of writing, an interplay between what Vygotsky calls the indicative and symbolic functions of writing.

If students are exposed to several different media at once, though, we caution that they not be overwhelmed. Numerous students found it challenging to deal with several media, not so much because any given medium was difficult but because some students were new to them (especially

concept mapping) and because it was difficult to efficiently juggle several media at once. Susan, who was generally exuberant about the course ('I feel like I'm just tapping that fund of creativity again...this class has taught me a whole new way of thinking') did grow weary of the number of revisions and was frustrated by the learning curve for dealing with new technology. Jessica, an enthusiast about the course in general, found it 'kinda hard to get to the computer lab three times a week.'

Conclusion

It was hoped that use of electronic journaling and concept mapping would promote sustained reflection (as demonstrated in the quality of revised concept maps and quality of revised drafts of the culminating paper). On the surface we were disappointed. Most students had never even thought about the nature of science before (despite having spent countless hours in lecture halls and laboratories) and 16 weeks was simply not long enough for them to articulate and then refine or change their initial propositions. Reflection as measured by change in propositions did not happen. This lack of demonstrated changed in their concept maps leads us to believe that most students were doing all they could to absorb new ideas and begin to make sense of them. If, however, reflection stems from certain habits of questioning and from heightened skepticism and discrimination of sources of evidence, then most students displayed many behavioral changes (Appendix F). As Sam conceded about the electronic journaling, 'I value some people's opinion in class more than others.' This heightened an awareness of differences among 'expert opinions' and that all 'experts' don't speak with the same authority. As students were pressed to develop more levels for their concept maps, they began to reach for more citations. They also sought more feedback, sometimes going beyond the requirements to review multiple 20-page drafts of the final paper. From a Vygotskian perspective, students sought guided participation.

We hoped that the electronic medium might foster what Donald Schon (1983, 1987) called 'reflective conversation' among these 17 emerging science education professionals. According to Schon, professionals are characterized in part by their reflective conversation, the 'artful inquiry' into situations of uncertainty involving taking stances, experimenting, and learning from the 'backtalk' of the situation. Students enrolled in Science in the Secondary School had many opportunities for backtalk: oral backtalk via class discussions, written backtalk through journaling, written backtalk through teacher feedback and student revision of the concept maps, and backtalk through teacher feedback and student revision of the written papers. While the actual statements or propositions in the journals, concept maps, and culminating paper did not change markedly, students displayed behaviors and habits of questioning that are conducive to 'reflective conversation,' and the electronic medium appeared to be a catalyst in the development of those behaviors. To what degree technology and social activity mediate cognitive activity, as Vygotsky suggestsed remains an open question, but our preliminary study suggests that they are factors that should not be ignored.

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Appendix A: Sample Post from the Electronic Journal

Electronic Journaling

From: Tina

Subject: Nature of Science

Hell-o Dr _____

I though todays discussion went well, but I felt that people were holding back to prevent arguments. (I myself included) What do I think science is? I think science is a method of investigation that helps explain the world around us. It is not without its pro's and con's,

but overall I think it is a worthy endeavor. I think we need to concentrate more on how to teach science applicably and let the students discover first hand the thrill of it. Moral and ethics also need to be taught, but at the students current level of cognition.

I like the experimentation side of science. I think the 'scientific method' is out of date when it comes to research. I know in my own work research articles are reviewed and/or trial and error comes into play. I like hard core facts and statistics. I feel the only way you can eliminate the manipulation of numbers is by reproducing your results. I believe that is the standard now in current research.

Well, anyway I guess that is what I think. I don't know how much you want me to write. There are so many parameters and dimensions to this subject that it is impossible to discuss them all. I mentioned a few but that only scratches the surface. See you Monday.

Tina

Appendix B: Levels of Reflective Judgment (Kitchener & King, 1984)

Stage One: Beliefs simply exist; they are not derived. Justification is unnecessary.

Stage Two: Beliefs either exist or are based on the absolute knowledge of a legitimate authority.

Stage Three: While waiting for absolute knowledge to become available, people temporarily believe whatever they choose to believe.

Stage Four: The individual is the ultimate source and judge of his or her own truth.

Stage Five: Beliefs are justified with appropriate decision rules for a particular perspective or context.

Stage Six: Beliefs are justified for a particular issue by using generalized rules of evidence and inquiry.

Stage Seven: Beliefs reflect solutions that can be justified as most reasonable using general rules of inquiry or evaluation. Criteria for evaluation may vary from domain to domain, but the assumption that ideas, beliefs, etc. may be judged as better or worse approximations to reality remains constant.

Appendix C: Evidence of a Reflective Judgment Stage Three Thinking

> I understand that I will most likely be repeating a lot of what

>has already been said about the nature of science, but I will restate it

>anyway because It is hard to keep 19 messages strait about who said what.

> I agree that there are probably many different definitions of

>science, and as c548777 (eame not given) statEd, **truth is in the eye of**

>the beholder and knowledge is forever changing. I believe that it is

>extremely important to teach our students that knowledge, its level,

>depth, and concepts are always changing. The nature of science requires

>that we give our students the techniques and fundamentals to acquire

>knowledge, and encourage their drive to do so.

> I do not however, believe as someone else stated, that it

>is our job to teach the student's values. I don't think the nature of

>science includes the completely subjective and culturally laden values. I

>do beleive that we must teach our students ethics. As far as the nature of

>science is concerned, it is often in scientific fields that we increase our

> level of technology before we increase our level of understanding of it's

>consequences. I believe that we must explain to our students the

>consequences of scientific advancement, and also give them the ethical

>background and ability to make constructive decisions regarding science

>and technology.

>

>Aimee

Appendix D: Levels of authority/evidence

- Knowledge based on data, evidence, research
- Knowledge based on theory
- Knowledge based on reasoned argument
- Knowledge based on particular expert authority
- Knowledge based on word of the instructor
- Knowledge based on personal example or experience
- Knowledge based on peers' opinion or experience
- Knowledge based on opinion

Note: This hierarchy was devised by one of the authors to encourage students to offer support for their arguments in their writing assignments.

Appendix E: Electronic Post Based on Multiple Sources of Evidence; Post Suggesting a Potential Reflective Judgment Stage Five-Six

Appendix F: Behaviors and Habits of Questioning Conducive to Reflection

- Articulating tentative ideas
- Establishing relationships between new and old ideas
- Admitting uncertainty
- Posing questions
- Seeking more information
- Soliciting feedback
- Comparing and contrasting ideas
- Being open to change
- Demanding evidence or verification
- Discriminating among sources of authority
- Questioning the quality of evidence
- Organizing ideas logically
- Developing arguments

Note: This list was inferred from the patterns observed in student writing.

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