WebGuide: Guiding Collaborative Learning on the Web with Perspectives

ABSTRACT:

We are developing a Web-based tool called WEBGUIDE to mediate and structure collaborative learning. This software uses an innovative mechanism to define a flexible system of perspectives on a shared knowledge construction space. WEBGUIDE provides an electronic and persistent workspace for individuals and teams to develop and share distinctive points of view on a topic. We are designing the software and associated usage practices by trying it out in a middle school classroom and an advanced graduate seminar. Our experience in these use situations has raised a range of questions concerning theoretical and practical issues, which are driving our research. This paper is a reflection on what we are learning collaboratively about how software artifacts can mediate learning and shared cognition.

1. INTRODUCTORY NARRATIVE

For some years now I have been interested in how to personalize the delivery of information from knowledge repositories to people based on their preferred *perspectives* on the information (Stahl, 1995, 1996). For instance, designers often critique an evolving design artifact from alternative technical points of view; different designers have different personal concerns and styles, requiring considerations based upon access

to different rules of thumb, rationale, constraints, standards and other forms of domain knowledge. Computer design environments should support these important interpretive perspectives (Stahl, 1993a, 1993b). I am now primarily interested in applying similar mechanisms of perspectival computer support within contexts of collaborative learning (Stahl, 2000).

Last year, Ted Habermann – an information architect at NOAA who makes geophysical data available to school children over the Web – suggested to me that we try to develop some computer support for a project at his son's middle school. Dan Kowal, the environmental sciences teacher at the Logan School for Creative Learning in Denver, was planning a year-long investigation of alternative perspectives on the issue of "acid mine drainage" (AMD) – the pollution of drinking water supplies by heavy metals washed out of old gold mines. The fact that Dan and I were interested in "perspectives" from different perspectives seemed to provide a basis for fruitful collaboration. Ted obtained NSF funding for the project and we all spent last summer (1998) planning the course and its perspectives-based software. Each of us brought in colleagues and worked to create a Java application (WEBGUIDE), a set of auxiliary web pages, a group of adult mentors representing different perspectives on AMD and a course curriculum.

The class started in September and the software was deployed in October. The students in Dan's class were aware of the experimental nature of the software they were using and were encouraged to critique it and enter their ideas into WEBGUIDE. Feedback from these twelve-year-old students provided initial experience with the usability of WEBGUIDE and resulted in a re-implementation of the interface and optimization of the algorithms over Christmas vacation.

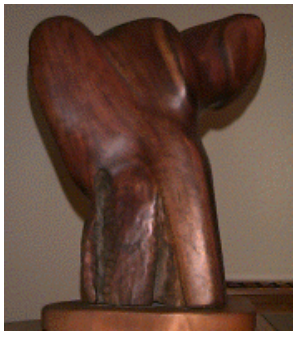
In January 1999, I organized an interdisciplinary seminar of doctoral students from cognitive, educational and computational sciences to study theoretical texts that might provide insight into how to support collaborative learning with perspectives-based software. The seminar uses WEBGUIDE as a major medium for communication and reflection, including reflection on our use of the software. This provides a second source of experience and raises a number of issues that will need to be addressed in software redesign this summer.

In this paper I would like to begin a reflection on the issues that have arisen through our WEBGUIDE experiences because I think they are critical to the ability to support collaborative learning with computer-

based environments. The potential for computer mediation of collaboration seems extraordinary, but our experience warns us that the practical barriers are also enormous. Certainly, our experiences are not unique, and similar projects at the universities of Toronto, Michigan, Berkeley, Northwestern, Vanderbilt, Georgia Tech, etc. have run into them for years. Indeed, we observed many of these issues in a seminar last year prior to the implementation of WEBGUIDE (dePaula, 1998; Koschmann & Stahl, 1998). However, I believe that perspectives-based software addresses or transforms some of the issues and raises some of its own.

Now let me describe how computer support for perspectives has evolved in WEBGUIDE. I will first discuss the preliminary implementation as used in Dan's middle school environmental course and explain how perspectives are supported in that version. A number of design issues led to an extended attempt to bring theory to the aid of reflection on practice. This included a graduate seminar that used a revised version of WEBGUIDE. Finally, following this paper is a slightly condensed version of the dialog that took place between the JIME reviewers and the author, where responses from Winter 2000 and Spring 2001 bring in reflections from subsequent design iterations.

2. PRACTICE I: ENVIRONMENTAL PERSPECTIVES



An early implementation of WEBGUIDE is in use in Dan's classroom at the Logan School. For the past five years, his class of middle school students has researched the environmental damage done to mountain streams by "acid mine drainage" from deserted gold mines high in the Rocky Mountains above Denver. The students actually solved the technical problem at the source of a stream coming into Boulder from the Gamble Gulch mine site by building an artificial constructed wetlands area to filter out heavy metals. This year they are investigating the broader ramifications of their success; they are looking at the social issue of acid mine

drainage from various alternative – and presumably conflicting – perspectives. The students interview adult mentors to get opinions from specific perspectives: environmental, governmental, mine-owner and local landowner. Then, working in teams corresponding to each of these perspectives, they articulate the position of their perspective on a set of shared questions.

The "Gamble Gulch" application of WEBGUIDE serves as the medium through which the students collaboratively research these

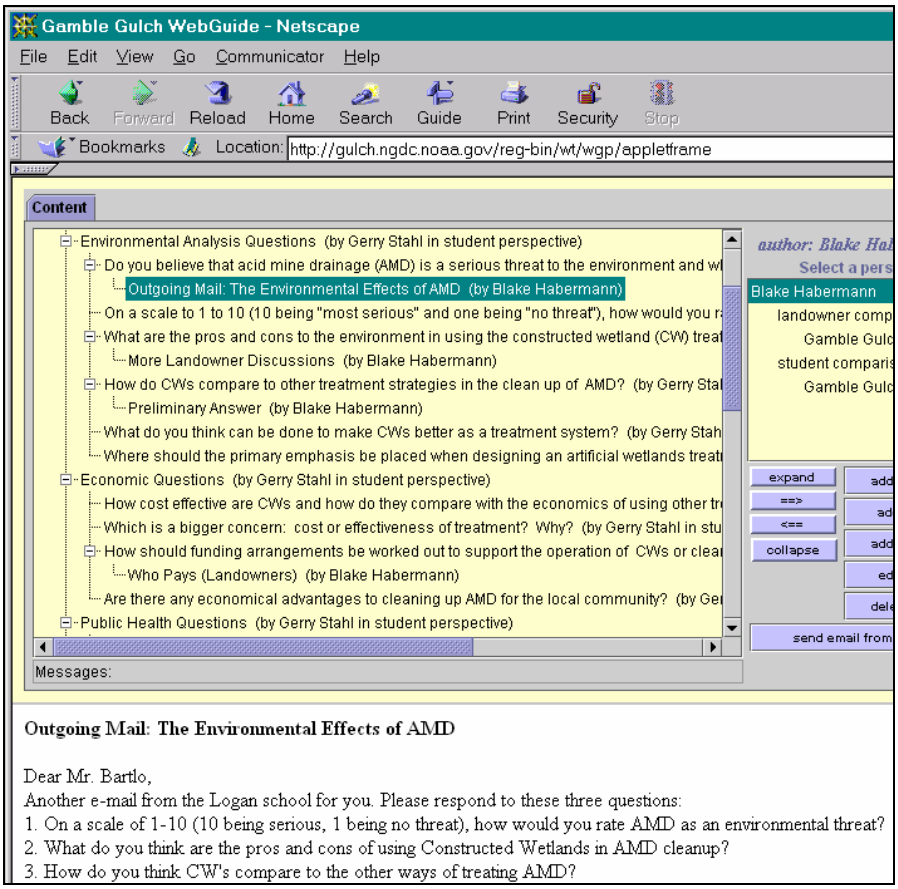


Figure 1. The Gamble Gulch version of *WEBGUIDE* viewed in a Web browser. The top part is a Java applet displaying an outline view of note titles. The content of the selected note is displayed in an HTML frame below. To the right are buttons for navigating the outline and changing the content in the shared knowledge space. The view shown is from the personal perspective of one student.

issues with their mentors and with teammates. Each student and mentor has their personal display perspective, and their display perspectives each inherit from one of the content-based team perspectives (environmental protection, governmental regulation, etc.), depending upon which intellectual perspective they are working on constructing.

Figure 1 shows one student's (Blake) personal perspective on the class discourse. The tree of discussion threads was "seeded" with question categories, such as "Environmental Analysis Questions." Within these categories, the teacher and I posted specific questions for the students to explore, like, "Do you believe that AMD is a serious threat to the environment?" Here, Blake has sent an email to a mentor asking for information related to this question. Email interactions happen through WEBGUIDE and are retained as notes in its display perspectives. When replies are sent back, they are automatically posted to the discussion outline under the original email. When someone clicks on a title, the contents of that note are displayed in an HTML frame below the applet (as is the body of the student's email in Figure 1).

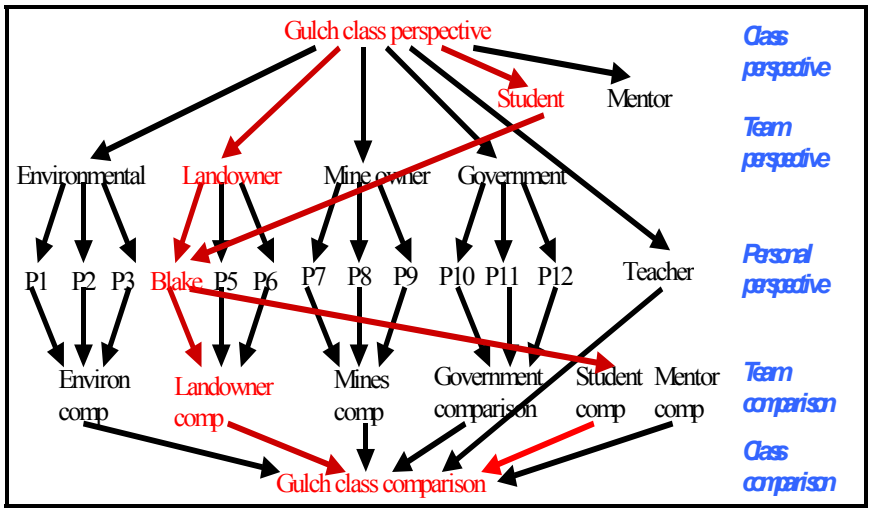


Figure 2. The web of perspectives in Gamble Gulch. Information is automatically inherited downward in the diagram. Blake's perspective includes all the notes entered in the Gulch class, Landowner and Student perspectives. His notes also show up in the Landowner, Student and Gulch class comparison perspectives.

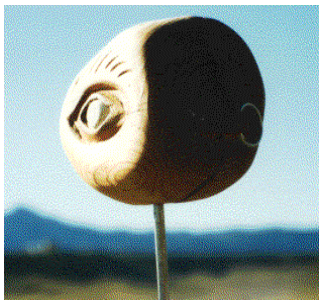
Blake is working in his personal perspective, which inherits from the Class, Student team and Landowner team perspectives (see the red arrows in Figure 2). Note that the display of his personal perspective (in Figure 1) includes notes that Dan and I entered in the Student perspective to structure the work of all the students. Blake can add, edit and delete ideas in his perspective, as well as sending email in it. Because he is a member of the landowner team and the student group as well as the class, he can browse ideas in the Student comparison, the Landowner comparison and the Gamble Gulch class comparison perspectives (see list of perspectives accessible to him on the right of Figure 1).

For this application, the teacher has decided that perspective comparing and negotiation will take place in live classroom discussions, rather than in WEBGUIDE. After a team or the whole class reaches a consensus, the teacher will enter the statements that they have agreed to into the team or class perspective.

The goal of the year-long course is not only to negotiate within teams to construct the various positions, but also to negotiate among the positions to reach consensus or to clarify differences. Dan designed this class – with its use of WEBGUIDE – to teach students that knowledge is perspectival, that different people construct views, compilations of facts and arguments differently depending upon their social situation. He hopes that his students will not only learn to evaluate statements as deriving from different perspectives, but also learn to negotiate the intertwining of perspectives to the extent that this is possible.

3. COMPUTER SUPPORT OF PERSPECTIVES

The term "perspectives" is over-loaded with meanings; this frequently produces confusion even when it is intended to tacitly exploit aspects of the perspectives metaphor from one domain into another. It may be helpful at this point to distinguish three types of perspectives: literal, figurative and computational.



- *Literal perspectives* are optical

or perceptual orientations: one sees objects from the specific angle or vantage point of the physical location of one's eyes.

- *Figurative perspectives* take metaphorical license and refer to, for instance, different ways of conceptualizing a theme, as in adopting a skeptical view of a conversational claim.
- *Computational perspectives* are the result of software mechanisms that classify elements in a database for selective display. In WEBGUIDE, for example, if I enter a note in my personal perspective then that note will be displayed whenever my perspective is displayed but not when someone else's personal perspective is displayed.

WEBGUIDE implements a system of computational (i.e., computer-supported, automated) perspectives designed to exploit the perspective metaphor in order to support characteristics of collaboration and collaborative learning. It is unique in a number of ways that distinguish it from other software systems that may use the term "perspectives":

- Other systems refer to different *representations* of information as perspectives. They might have a graphical and a textual view of the *same* data. In WEBGUIDE, different data is displayed in different perspectives – using the same representation, hierarchically structured titles of textual notes.
- In WEBGUIDE, the perspectives mechanism is neither a simple tagging of data nor a database view, but is a dynamic computation that takes into account a *web of inheritance* among perspectives. Thus, Blake's perspective includes not only information that he entered in his perspective, but also information inherited from the Class, Student and Landowner perspectives.
- Furthermore, the web of perspectives can be extended by users *interactively* and the inheritance of information is always computed based on the current configuration of this web.
- In addition, the information in a perspective has a user-maintained structure in which each note has one or more parent notes and may have children notes, creating a *web of notes* within each perspective. The order of children displayed under a parent note is user-defined and maintained

so that WEBGUIDE can be used to *organize ideas* within outline structures.

The idea of perspectives on the Web traces its lineage to ideas like "trail blazing" (Bush, 1945), "transclusion" (Nelson, 1981), and "virtual copies" (Mittal, Bobrow, & Kahn, 1986) – techniques for defining and sharing alternative views on large hypertext spaces. At the University of Colorado we have been exploring this approach to computational perspectives in desktop applications for the past decade (McCall *et al.*, 1990; Stahl, 1993a). WEBGUIDE is our first truly Web-based version. The core of WEBGUIDE consists of a perspectives server named POW! (Perspectives On the Web), which communicates with Java, Perl or HTML interfaces.

The computational perspectives mechanism we have been exploring incorporates the following features for a community of users (Stahl, 1993b):

- Individual community members have access to what appears to be their own information source. This is called their *personal perspective*. It consists of notes from a shared central information repository that are tagged for display within that particular perspective (or in any perspective inherited by that perspective).
- Notes can be created, edited, rearranged, linked together or deleted by users within their own personal perspective without affecting the work of others.
- Another student, Annie, can integrate a note from Blake's perspective into her own personal perspective by creating a *link* or virtual copy of the note. If Blake modifies the original note, then it changes in Annie's perspective as well. However, if Annie modifies the note, a new note is actually created for her, so that Blake's perspective is not changed. This arrangement generally makes sense because Annie wants to view (or inherit) Blake's note, even if it evolves. However, Blake should not be affected by the actions of someone who copied one of his notes.
- Alternatively, Annie can *physically copy* the contents of a note from Blake's perspective. In this case, the copies are not linked to each other in any way. Since Annie and Blake are viewing physically distinct notes now, either can make changes without affecting the other's perspective.

- There is an inheritance web of perspectives; descendants inherit the contents of their ancestor perspectives. Changes (additions, edits, deletions) in the ancestor are seen in descendent perspectives, but not vice versa. New perspectives can be created by users. Perspectives can inherit from existing perspectives. Thus, a team comparison perspective can be created that inherits and displays the contents of the perspectives of the team members. A hierarchy of team, sub-team, personal and comparison perspectives can be built to match the needs of a particular community (Figure 2).

This model of computational perspectives has the important advantage of letting team members inherit the content of their team's perspective and other information sources without having to generate it from scratch. They can then experiment with this content on their own without worrying about affecting what others see. This is advantageous as long as one only wants to use someone else's information to develop one's own figurative perspective. Such "perspective-making" is important in thinking about and judging issues from particular perspectives.

However, if one wants to influence the content of other team members' perspectives through "perspective-taking" (Boland & Tenkasi, 1995), then this approach is limited because one cannot change someone else's content directly. Moreover, for supporting collaborative work it is important that the perspectives maintain at least a partial overlap of their contents in order to reach successful mutual understanding and coordination. The underlying subjective opinions must be intertwined to establish intersubjective understanding (Tomasello, Kruger, & Ratner, 1993). We are interested in exploring how to support the intertwining of perspectives with our computational perspectives mechanisms. We will return to this issue after describing the types of perspectives used in our applications.

4. TYPES OF PERSPECTIVES

WEBGUIDE provides several levels of perspectives (see Figure 2) within a web of

perspective inheritance to help students compile their individual and joint research:

- The *class perspective* is created by the teacher to start each team off with an initial structure and some suggested topics. It typically establishes a framework for classroom activities and defines a space used to instantiate the goal of collecting the products of collaborative intellectual work.
- The *team perspective* contains notes that have been accepted by a team. This perspective can be pivotal; it gradually collects the products of the team effort.
- The student's *personal perspective* is an individual's work space. It inherits a view of everything in the student's team's perspective. Thus, it displays the owner's own work within the context of notes proposed or negotiated by the team and class – as modified by the student. Students can each modify (add, edit, delete, rearrange, link) their virtual copies of team notes in their personal perspectives. They can also create completely new material there. This computational perspective provides a personal workspace in which a student can construct his or her own figurative perspective on shared knowledge. Other people can view the student's personal perspective, but they cannot modify it.
- The *comparison perspective* combines all the personal perspectives of team members and the team perspective, so that anyone can compare all the work that is going on in the team. It inherits from personal perspectives and, indirectly, from the team and class perspectives. Students can go here to get ideas and copy notes into their own personal perspective or propose items for the team perspective.

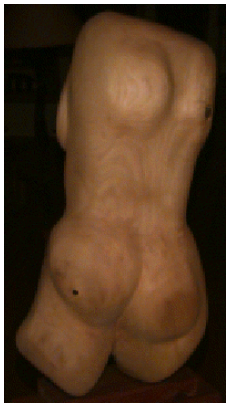
Of course, there is not really a duplication of information in the community memory. The perspectives mechanism merely displays the information differently in the different perspectival views, in accordance with the relations of inheritance.

To design software for collaborative learning in schools means to design curriculum and classroom process as well (Stahl, Sumner, & Owen, 1995; Stahl, Sumner, & Repenning, 1995). Computer support has to be matched with appropriate content (typically stored in WEBGUIDE or on the Web) and with constructivist practices for knowledge-building communities (Scardamalia & Bereiter, 1991). The

design of the WEBGUIDE interface and the perspectives mechanism must be adapted to individual application situations, with appropriate seeding of content, structuring of the perspectives web and establishing of access policies.

In Logan School, for instance, students each enter notes in their personal perspectives using information available to them: from the Web, books, encyclopedia, discussions, interviews of mentors or other sources. Students can review the notes in the class perspective, their team perspective and the personal perspectives of their teammates. All of these contents are collected in comparison perspectives, where they are labeled by their perspective of origin. Students extract from the research those items that are of interest to them. Then they organize and develop the data they have collected by categorizing, summarizing, labeling and annotating. The stages of investigating, collecting and editing can be iterated as many times as desired. Team members then negotiate which notes should be promoted to the team perspective to represent their collaborative statement of their team's perspective on acid mine drainage.

5. ISSUES FOR PERSPECTIVES



As an initial field testing of the WEBGUIDE system, the Logan School trial is generating valuable experience in the practicalities of deploying such a sophisticated program to young students over the Web. The students are enthusiastic users of the system and offer (within WEBGUIDE) many ideas for improvements to the interface and the functionality. Consequently, WEBGUIDE is benefiting from rapid cycles of participatory design. The differing viewpoints, expectations and realities of the software developers, teachers and students provide a dynamic field of constraints and tensions within which the software, its goals and the understanding of the different participants co-evolve.

The first issues to hit home when we deployed WEBGUIDE were the problems of response time and screen real estate. The student computers were slower, had smaller monitors, lacked good Internet

connections and were further from the server than the computers of the developers. We were, of course, already familiar with these issues from other Web applications, but one never knows quite how things will work out and how they will be accepted until one tests them under classroom conditions.

A pre-release prototype of WEBGUIDE used dynamic HTML pages. This meant that each time one expanded a different part of the outline of titles one had to wait for a new page to be sent across the Internet. It also greatly constrained the interface functionality. However, when we moved to a Java applet, we had to wait several minutes to download the applet code to each student computer. Furthermore, it entailed running all the perspectives computations on the slow student computer. In order to reduce the download time significantly, we first rewrote the interface using standard Java Swing classes that can be stored on the student machines. Then we split the applet into a client (the interface) and a server (the perspectives computations and database access). By downloading only the client part to the classroom, we not only reduced the download time further, but also ran the time-consuming computations on our faster server computers.

Such technical problems can be solved relatively easily, by optimizing algorithms or by adjusting tradeoffs based on local conditions. Issues of social practice are much more intransigent. There seem to be two major issues for software like WEBGUIDE, that is, software for threaded discussions and collaborative knowledge construction:

1. Lack of convergence among the ideas developed in the supported discussions.
2. Avoidance of system use in favor of email, face-to-face conversation or inaction.

WEBGUIDE introduces its computational perspectives mechanism as a structural feature to facilitate the articulation of convergent ideas and even incorporates email. In attempting to address the above problems, it raises a new set of issues:

3. Is the perspectives metaphor a natural one (or can it be made natural) so that people will use computational perspectives to construct their figurative perspectives?
4. Can the web of perspectives be represented in a convenient and understandable format?

In our trials of WEBGUIDE we have tried to create learning situations that would encourage the use of the software, yet we have observed low levels of usage and under-utilization of the system's full functionality. This raises the following additional issues:

5. How can learning situations be structured to take better advantage of the presumed advantages of the software?
6. How can the system's various capabilities be distinguished, such as its support for threaded discussions and for perspective-making?

In order to answer questions of this magnitude it was necessary to gather more experience, to be more closely involved in the daily usage of the system and to develop a deeper theoretical understanding of collaborative learning and of computer mediation. Having defined these goals, I announced a seminar on the topic of "computer mediation of collaborative learning," open to interested researchers from a number of disciplines – primarily education, cognitive psychology and computer science. The goal of the seminar was explicitly stated to be an experiment in the use of WEBGUIDE to construct knowledge collaboratively, based on careful reading of selected texts. The texts traced the notion of *computer mediation* (Boland & Tenkasi, 1995; Caron, 1998; Hewitt et al., 1998; Scardamalia & Bereiter, 1996; Stahl, 2000) back to *situated learning theory* (Bruner, 1990; Cole, 1996; Lave, 1991; Lave & Wenger, 1991; Lave, 1996) – and from there back to the notion of *mediated consciousness* in Vygotsky (Vygotsky, 1930/1978) and its roots in Hegel (Habermas, 1971; Hegel, 1807/1967; Koyeve, 1947/1969) and Marx (Marx, 1844/1967; Marx, 1845/1967, 1867/1976).

In Section 8 of this paper I will comment on our current understanding of the six issues listed above. But first it is necessary to describe the ways in which the seminar attempts to make use of WEBGUIDE and the conceptualization of the theory of computer mediation that is arising in the seminar.

6. PRACTICE II: THEORETICAL PERSPECTIVES

The seminar on computer mediation of collaborative learning is designed to use WEBGUIDE in several ways:

- *As the primary communication medium for internal collaboration*. The seminar takes place largely on-line. Limited class time is used for people to get to know each other, to motivate the readings, to introduce themes that will be followed up on-line, and to discuss how to use WEBGUIDE within the seminar.
- *As an example collaboration support system to analyze*. Highly theoretical readings on mediation and collaboration are made more concrete by discussing them in terms of what they mean in a system like WEBGUIDE. The advantage of using a locally-developed prototype like WEBGUIDE as our example is that we not only know how it works in detail, but we can modify its functionality or appearance to try out suggestions that arise in the seminar.
- *As an electronic workspace for members to construct their individual and shared ideas*. Ideas entered into WEBGUIDE persist there, where they can be revisited and annotated at any time. Ideas that arise early in the seminar will still be available in full detail later so that they can be related to new readings and insights. The record of discussions over a semester or a year will document how perspectives developed and interacted.
- *As a glossary and reference library*. This application of WEBGUIDE is seeded with a list of terms that are likely to prove important to the seminar and with the titles of seminar readings. Seminar members can develop their own definitions of these terms, modifying them based on successive readings in which the terms recur in different contexts and based on definitions offered by other members. Similarly, the different readings are discussed extensively within WEBGUIDE. This includes people giving their summaries of important points and asking for help interpreting obscure passages. People can comment on each other's entries and also revise their own. Of course, new terms and references can be added easily by anyone.
- *As a brainstorming arena for papers*. The application has already been seeded with themes that might make interesting research papers drawing on seminar readings and goals. WEBGUIDE allows people to link notes from anywhere in the

information environment to these themes and to organize notes under the themes. Thus, both individuals and groups can use this to compile, structure and refine ideas that may grow into publishable papers. Collaborative writing is a notoriously difficult process that generally ends up being dominated by one participant's perspective or being divided up into loosely connected sections, each representing somewhat different perspectives. WEBGUIDE may facilitate a more truly collaborative approach to organizing ideas on a coherent theme.

- *As a bug report mechanism or feature request facility*. Seminar participants can communicate problems they find in the software as well as propose ideas they have for new features. By having these reports and proposals shared within the WEBGUIDE medium, they are communicated to other seminar participants, who can then be aware of the bugs (and their fixes) and can join the discussion of suggestions.

The seminar version of WEBGUIDE incorporates a built-in permissions system that structures the social practices surrounding the use of the system. Seminar participants each have their own personal perspective in which they can manipulate notes however they like without affecting the views in other perspectives. They can add quick discussion notes or other kinds of statements. They can edit or delete anything within their personal perspective. They can also make multiple copies or links (virtual copies) from notes in their personal perspective to other notes there. Anyone is free to browse in any perspective. However, if one is not in one's own perspective then one cannot add, edit or delete notes there (as in Figure 3). To manipulate notes freely, one must first copy or link the note into one's own personal perspective. The copy or link can optionally include copying (or virtual copying) all the notes below the selected note in the tree as well. These rules are enforced by the user interface, which checks whether or not someone is in their personal perspective and only allows the legal actions.

Students in the class can form sub-groups either within or across their different disciplines. They develop ideas in their personal perspectives. They debate the ideas of other people by finding notes of interest in the class comparison perspective (or in a subgroup comparison perspective) and copying these notes into their own

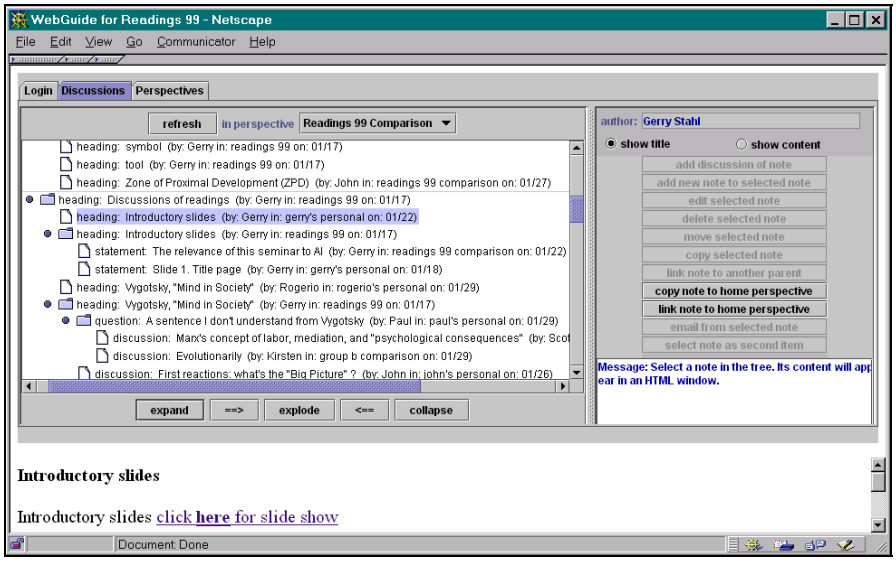


Figure 3. The version of WEBGUIDE used in the seminar. Note that some of the control buttons on the right are not functional when the logged-in author is not working in his own personal perspective. This enforces certain social practices. Also note that many headings have been inserted to structure the discussion space.

personal perspective, where they can comment on them. The clash of perspectives is visible in the comparison perspectives, while the personal perspectives allow for complete expression and organization of a single perspective. This supports the "taking" of other people's perspectives and the use of shared ideas in the "making" of one's own perspectives (Boland & Tenkasi, 1995).

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The seminar application of WEBGUIDE stresses the use of perspectives for structuring collaborative efforts to build shared knowledge. The goal of the seminar is to evolve theoretical views on computer mediation – and to do so within a medium that supports the sharing of tentative positions and documents the development of ideas and collaboration over time. A major hypothesis investigated by the seminar is that software environments with perspectives – like WEBGUIDE – can provide powerful tools for coordinated intellectual work and collaborative learning. It explores how the use of a shared persistent knowledge construction space can support more complex discussions than ephemeral face-to-face conversation. Many of the desires and concerns in this paper arose in notes in WEBGUIDE as part of the seminar. In particular, the seminar's focus on theory as our practice has problematized our understanding of the role of theory.

7. THEORY IN PRACTICE

Our initial application of WEBGUIDE in the middle school environmental course raised a number of issues that led us to seek theoretical understanding through a seminar, which is serving as a second application of WEBGUIDE. We have begun to see our research differently as a result of the theories we are incorporating in our reflections within the seminar. One thing that has changed is the relation we see of this theory to our research practice.

In my paper proposal to AERA – the first draft of this paper – written prior to our recent explorations, I described our approach by following the narrative order implied by conventional wisdom about the relation of theory to practice. After stating the goal or purpose of the work, I provided a theoretical framework, followed by sections on techniques, evidence, conclusions and educational / scientific import. The assumption here was that when one had a problem one turned first to theory for the solution and then "applied" the theory to some situation – either the problem situation or an experimental test context. After designing the solution based on the pre-existing theory and applying it to the test situation, one gathered evaluative data and

analyzed the data to measure success. The evaluation then implies whether or not the solution has generalizable import.

But such an approach is in keeping neither with our current experience nor with our emerging theory. We started last summer with an opportunity to explore some vague notions we had about something we called "perspectives". We experimented with ever-evolving techniques through a complex collaborative process involving many people, each with their own concerns, understanding and insights. As part of this process some of us turned to theory – but the selection of theoretical texts and our interpretations of them were determined by the processes and issues we observed in our practical strivings.

So in this draft of the paper – still not considered a static final document, but a recapitulation from one particular moment in an on-going process – I am trying to narrate a different story about how theory and practice have been co-mingled in our research. We began with an idea for a concrete classroom curriculum and worked on designing tools and structures to support the practical needs of that curriculum. Once we had a working software prototype that could be used over the Web, we deployed it in the middle school classroom. We immediately confronted the realities of issues of response speed and monitor screen real estate that we had been worried about from the start. Students started asking for new functionality and it became clear that they were not using the implemented functions the way they were designed to be used. A dance commenced between the technicians, the educators, the students, the curriculum and the software; as we circled each other, we changed and became more compatible with each other.

There was no point in trying to evaluate the success of our experiment by gathering data under controlled conditions. It was clear that we needed to figure out how to make things work better, not to measure precisely how well they were (or were not) already working. Beyond the relatively clear technical usability issues there were deeper questions of how software can mediate interpersonal and cognitive relations within collaboration (Hewitt, Scardamalia, & Webb, 1998). This led us to look for a theory of computer mediation – and for that matter a theory of collaborative learning – in the graduate seminar. Of course, it turned out that there are no theories on these topics sitting on the bookshelf adequate for us to simply apply. Rather, we had to undertake the construction of such theory, building upon hints strewn

around in texts from many disciplines and guided by the problematic in which we are involved first hand.

Trusting in our intuition that software like WEBGUIDE could facilitate group theory building, we set out to use WEBGUIDE in our theoretical investigations, and thereby drive the further development of the software through additional practical experience even as we were developing theoretical justifications for our design. In reflecting on our experience, I have tried to organize this draft of the paper in accordance with a non-traditional theory about the relation of theory and practice – an understanding of this relationship more in keeping not only with our practice but with our hermeneutic, dialectical, socially situated activity theory.

Thus, we started out from our vague, only partially articulated background understanding of perspectives as an interesting and promising concept for learning and for computer support (Stahl, 1993b). We set up a real-world situation in which we could explore what happens. In this situation we nurtured a process of "structural coupling" (Maturana & Varela, 1987) in which the different actors evolve toward a workable synthesis or homeostasis. Rapid prototyping cycles and participatory design sessions help facilitate this process. As breakdowns in how things were intended to work are recognized, we engage in reflection-in-action (Schön, 1983) to make our tacit pre-understanding explicit, to understand what has happened and to project corrective actions. This process of explication raises generalizable issues and calls for theory. But despite the generality of the issues, the theory is not understood in a completely abstract way, but in terms of its relevance to our situation and to the specific barriers we have uncovered in that concrete situation.

Theory – like everyday thought – often arises after the fact (or well into the complex process of practical investigations) in order to justify situations that would otherwise be too messy to comprehend and remember. Then, first chance it gets, theory reverses the order of things and presents itself as a guiding *a priori*. As Hegel (Hegel, 1807/1967) says, "the owl of Minerva flies only at night": the wisdom of theory arrives on the scene only after the practical events of the day (which theory captures in concepts) have been put to bed. *Theory* is a cherished way to capture an understanding of what has been learned, even if it distorts the picture by claiming that the practice out of which theory

arose was a simple application of the theory's pre-existing abstract principles.

But, as the analyses of mediated cognition our seminar is studying point out, there are other *artifacts* (Cole, 1996) in which experience can be captured, preserved and transmitted. *Narrative* is one (Bruner, 1990). In this paper I have tried to project a voice which does not redefine the temporality of the experience I am reporting.

Sculpture is another way in which people impose meaningful form on nature and, as Hegel would say, externalize their consciousness through the mediation of wood, clay, plaster or stone – sharing it with others and preserving it as part of their culture's spirit. The sculptures decorating this paper are such artifacts, which create spaces that project their own perspectives while being perceived from observational vantage points. Of course, my sculptures are not the result of some primordial experience of self-consciousness interacting with unmediated nature. They are late twentieth century explorations of form and material. Here, organic three-dimensional forms are showcased to contrast with socially prevalent two-dimensional representations and with the geometric shapes produced by machinery. The characteristics of the materials of nature are brought forth, in contrast to the plastic substances that retreat from our consciousness in commodities. Also, the pragmatic representational function of symbolic objects is sublimated in the study of their abstracted physical forms and materiality. In negating the commonplace characteristics of signs – which point away from themselves – the non-representational sculptures obtrusively confront their creator and viewers with the nature of the artifact as intentionally formed material object.

Polished *software* is a very different way of objectifying experience. Buried in the source code and affordances of a software artifact are countless lessons and insights – not only those of the particular software developer, but of the traditions (congealed labor) of our technological world upon which that developer built (Marx, 1867/1976). This is true of the current version of WEBGUIDE, as it is of any software application. So the software application is an artifact that mediates classroom collaboration. But WEBGUIDE strives to preserve insights explicitly as well, within the notes displayed in its perspectives and within their organization, including their organization into personal and group perspectives. So the discussions that evolve within this medium are also artifacts, captured and organized by the perspectives.

Perhaps when we understand better how to use WEBGUIDE in collaborative learning contexts it will maintain the knowledge that people construct through it in a way that preserves (*aufheben*) the construction process as well as the resultant theory. Then we may have a type of artifact that does not reify and alienate the process by which it developed – that permits one to reconstruct the origin of collaborative insights without laboriously deconstructing artifacts that are harder than stone. Eventually, collaborative practice and software design may co-evolve to the point where they can integrate the insights of multiple perspectives into group views that do not obliterate the insights of conflicting perspectives into the multifaceted nature of truth.

8. ISSUES FOR MEDIATION

We conclude this paper with an attempt to sort out what we are collaboratively learning through our use of WEBGUIDE. The six issues for perspectives-based software like WEBGUIDE that arose during the middle school application (Section 5) appeared in the graduate seminar's usage of the software as well – and were articulated by seminar participants in their notes in WEBGUIDE. These are important and complex issues that other researchers have raised as well. They are not problems that we have solved, but rather foci for future work. They define central goals for our redesign of WEBGUIDE this summer and goals for structuring the mediation of collaborative practices next year.

Here is a summary of our current understanding of these issues, based on our two practical experiences and our reflections on the theory of computer mediation of collaborative learning:

8.1 Divergence among ideas

In his review of computer mediated collaborative learning, dePaula (dePaula, 1998) identified divergence of ideas to be a common problem. He argued that the tree structure imposed by standard threaded discussion support was inappropriate for collaboration. The idea of a threaded discussion is that one contribution or note leads to another, so that each new idea is connected to its "parent" in order to preserve this connection. The problem is that there is often no effective way to bring several ideas together in a summary or synthesis because that would require a particular note to be tied to several parent notes – something that is typically not supported by discussion software. The result is that discussions proceed along ever diverging lines as they branch out, and there is no systematic way to promote convergence. It seems clear, however, that collaboration requires both divergence (e.g., during brainstorming) and convergence (e.g., during negotiation and consensus).

WEBGUIDE tries to avoid this common structural problem of threaded discussion media at three levels: (1)The note linking mechanism in WEBGUIDE allows notes to be *linked* to multiple parents, so that they can act to bring together and summarize otherwise divergent ideas. As in threaded discussions, every note is situated in the workspace by being identified and displayed as the child of some other note. However, WEBGUIDE allows multiple parents, so that the web of notes is not restricted to a tree. (2) Similarly, the graph of perspectives allows for *multiple inheritance*, so that "comparison" perspectives can be defined that aggregate or converge the contents of multiple perspectives. The Logan School application was seeded with comparison perspectives corresponding to the class and subgroup perspectives, so that the overall perspectives graph has a structure in which the inheritance of notes first diverges from the class to the subgroup and then the personal perspectives, and then converges through the subgroup comparison perspectives to the class comparison perspective, as shown in Figure 2. The web of perspectives forms a directed acyclical graph rather than a strict hierarchy. (3) Another effective way to encourage a well-structured discussion is to seed the workspace with a set of headings to scaffold the discourse. By introducing carefully conceived *headings* high in the perspective inheritance network, a facilitator (such as a teacher) can define an

arrangement of topics that will be shared by the participants and will encourage them to arrange related ideas close to each other.

Although WEBGUIDE provided these three convergence mechanisms in both of our usage situations, most participants were not adept at using any of them. This is probably related to the other issues below and is something that needs to be explored further in the future.

8.2 Avoidance of system use

Media competition poses a barrier to acceptance of new communication software. People are naturally hesitant to adopt yet another communication technology. In a world inundated with pagers, cell phones, voicemail, email, fax, etc. people are forced to limit their media or be overwhelmed. They must calculate how much of a burden the new medium will impose in terms of learning how to use it, acquiring the equipment, checking regularly for incoming messages and letting people know that they are communicating through it. Clearly, a *critical mass* of adoption by one's communication partners is necessary as well.

In a classroom context, some of these problems are minimized: all one's partners are required to use WEBGUIDE and the hardware is made available. Yet, it is not so simple. The Logan School students have to communicate with mentors who may not have Internet access or the proper hardware. Communication with classmates is much easier face-to-face then typing everything (knowing it has to be carefully done for grading). In the graduate seminar, most participants do not have convenient access to the necessary equipment and have to go out of their way to a special lab. This means that they are lucky to communicate through WEBGUIDE once a week, and therefore cannot enter into lively on-going interchanges.

This summer we will have to make WEBGUIDE more accessible by increasing the number of platforms/browsers that it can run on and making it work over slow modems from home. Further, we need to improve its look-and-feel to increase people's comfort level in wanting to use it: speed up response time, allow drag-and-drop rearrangement of notes, permit resizing of the applet and fonts for different monitors and different eyes, support searching and selective printouts, provide graphical maps of the webs of perspectives and nodes.

8.3 Naturalness of the perspectives metaphor

Despite the fact that WEBGUIDE has been designed to make the perspectives metaphor seem natural and simple to navigate, people express confusion as to how to use the perspectives. What perspective should I be working in, browsing for other people's ideas or entering for discussions? The metaphor of perspectives as a set of alternative (yet linked and over-lapping) textual workspaces is a new notion when operationalized as in WEBGUIDE.

The fact that an individual note may have different edited versions and different linking structures in different perspectives, that notes may have multiple parents within the discussion threads, that new perspectives can be added dynamically and may inherit from multiple other perspectives sets WEBGUIDE apart from simple threaded discussion media. It also makes the computations for displaying notes extremely complex. This is a task that definitely requires computers. By relieving people of the equivalent of these display computations, computer support may allow people to collaborate more fluidly. This is the goal of WEBGUIDE. Although the software now hides much of the complexity, it is not yet at the point where people can operate smoothly without worrying about the perspectives.

8.4 Representation of the web of perspectives

One problem that aggravates acceptance of the perspectives metaphor is that the web of inheritance of content from perspective to perspective is hard to represent visually within WEBGUIDE. The WEBGUIDE interface relies on an *outline* display. This has many advantages, allowing users to navigate to and view notes of interest in an intuitive way that is already familiar. However, an outline display assumes a strictly hierarchical tree of information. Because the web of perspectives has multiple inheritance, its structure is not visible in an outline, which always shows a perspective under just one of its parents at a time. Thus, for instance, there is no visual representation of how a comparison perspective inherits from several personal perspectives.

The same is true at the level of notes. A note that has been linked to several other notes that it may summarize is always displayed as the child of just one of those notes at a time.

Two solutions suggest themselves for future exploration. One is to provide an alternative representation such as a *graphical map* in place of the outline view. As appealing as this sounds, it may be technically difficult to do on-the-fly. A bigger problem is that graphical maps are notoriously poor at scaling up. Already in our two trial situations – in which there are on the order of twice as many perspectives as participants – it would be hard to clearly label a graphical node for every perspective within the applet's confined display area. The second alternative is to indicate additional links with some kind of *icon* within the outline view. This would require more understanding on the part of the users in interpreting and making use of this additional symbolic information.

8.5 Structuring of learning situations

We have argued based on previous experience that the crucial aspect of supporting collaborative learning has to do with structuring social practices (Koschmann, Ostwald, & Stahl, 1998). *Practice* in the sense of Bourdieu's concept of *habitus* (Bourdieu, 1972/1995) is the set of generally tacit procedures that are culturally adopted by a community. In introducing WEBGUIDE into its two user communities, we have tried to establish certain usage practices, both by instruction and by enforcement in the software. Looking back at Figure 1, you can see that Logan students are only allowed to navigate to certain perspectives – namely their personal perspective and those group perspectives that inherit from that perspective. Seminar participants were originally given *permission* to navigate throughout the system and to make changes anywhere. That was subsequently modified (as shown in Figure 3) to restrict their abilities when not in their personal perspective. The governing principle was that everyone should be able to do anything they want within their personal perspective, but no one should be able to affect the display of information in someone else's personal perspective.

When the ability to enter notes everywhere was restricted, facilities for copying and linking notes from other computational perspectives into one's own computational perspective were introduced. This was intended to encourage people to integrate the ideas from other figurative perspectives into their own figurative perspective by making

a conscious decision as to where the new note should go in their existing web of notes. However, this added a step to the process of communication. One could no longer simply select a note that one wanted to comment on and press the "add discussion" button.

In order to facilitate discussion of notes that one did not necessarily want to integrate into one's own perspective, the "add discussion" button was then made active in all comparison perspectives. This led to minor problems, in that one could then not edit discussion notes that one had contributed in these perspectives. This could be fixed at the cost of additional complexity in the rules by allowing the author of a note to edit it in comparison perspectives.

More significantly, our experiments with changing permission rules pointed out that people were using WEBGUIDE primarily as a threaded discussion medium and rarely as a knowledge construction space. Furthermore, their ability to construct shared group perspectives on discussion topics was severely hampered by the lack of support for negotiation in the system.

8.6 Distinguishing the system's capabilities

In iterating the design of WEBGUIDE it became increasingly clear that what the system "wanted to be" was a *medium for construction of knowledge*. Yet, users were more familiar with discussion forums and tended to ignore the perspectives apparatus in favor of engaging in threaded discussion. These are very different kinds of tasks: collaborative knowledge construction generally requires a prolonged process of brainstorming alternative ideas, working out the implications of different options and negotiating conclusions; discussion can be much more spontaneous.

This suggests that more clarity is needed on the question: what is the *task*? If people are going to use WEBGUIDE for collaborative knowledge construction then they need to have a clear sense of pursuing a knowledge construction task. The Logan students have such a task in articulating positions on acid mine drainage. However, much of their knowledge construction takes place in classroom discussion. They use WEBGUIDE largely as a repository for their ideas. The seminar has been concerned with understanding a series of readings, so its participants have been more interested in exchanging isolated questions or reactions

than in formulating larger integrative positions. For the remainder of the seminar, we will be trying to develop ideas for a collaborative paper on the nature of computer collaboration. This may provide the kind of focused task needed to exercise more of WEBGUIDE's potential.

Our experience to date already suggests the complexity of trying to support collaborative learning. We should probably distinguish within the software interface functions that support discussion from those that support knowledge construction. But this should be done in such a way that spontaneously discussed ideas can later be readily integrated into longer-term knowledge construction processes. Similarly, additional functionality – most notably support for group negotiation – must be added, differentiated and integrated. New capabilities and uses of WEBGUIDE can increase its value, as long as confusions and conflicts are not introduced. For instance, providing facilities for people to maintain lists of annotated Web bookmarks, things-to-do, favorite references, up-coming deadlines, etc. within their personal perspectives might not only give them familiarity with using the system, but would also build toward that critical mass of usage necessary for meaningful adoption.

It has become a cliché that computer mediation has the potential to revolutionize communication just like the printing press did long ago. But the real lesson in this analogy is that widespread literacy required gradual changes in skills and practices in order to take full advantage of the technological affordances. In fact, the transition from orality to literacy involved a radical change in how the world thinks and works (Ong, 1998). Although social as well as technical changes can be propagated much faster now, it is still necessary to evolve suitable mixes of practices and systems to support the move from predominantly individual construction of knowledge to a new level of *collaborative cognition*.

Our investigation of the above six issues will guide the next stage of our on-going exploration of the potentials and barriers of computer mediated collaborative learning on the Web with perspectives.

9. DIALOG WITH JIME REVIEWERS

In Fall 2000, the preceding part of this paper was reviewed through the JIME on-line review process. I thought the reviews nicely brought out what the paper was trying to do. They added, in a generally supportive way, confirmation of one person's experiences from much broader backgrounds. The reflections on key issues significantly enriched the discussion.

Rather than disrupting the narrative flow of the report above, situated as it was in its particular phases of WEBGUIDE development, responses to the reviewer comments and inquiries will be presented in question/response format below. This may serve as another layer of reflection, from a somewhat later vantage point.

Since the reviewers did not take much advantage of the hypertext linking of reviews to paper sections, the comments of the three reviewers will be presented linearly below, interspersed by the author's responses. Stylistic issues that have been addressed through revisions to the body of the paper have been suppressed, leaving a sense of each reviewer's perspective on the substantive issues.

Helen Chappel-Hayios:

As the author describes, part of the unfolding story of the development of WEBGUIDE was that "A dance commenced between the technicians, the educators, the students, the curriculum, and the software: as we circled each other, we changed and became more compatible with each other" (Section 7). Within the dance the software was "polished" in the process of objectifying the experience. In these times of mass commercialization of online collaborative software, proprietary,

customized/ built for purpose collaborative learning software seems likely to increasingly be replaced as a matter of cost/convenience. In such a climate, it is both exciting and refreshing to read that specific learners and learning contexts can still sometimes lead the dance of software development! The point made by the author that "buried in the source code and affordances of a software artifact are countless lessons and insights" (Section 7), is a very timely and important one indeed.

As to originality, the complex linking and retrieval systems to shared resources seems highly original and very impressive. A slight doubt, which I think it would be hard to understand without using the system for a while, would be if it could feel/be restrictive. The point is made quite strongly referring to dePaula's work (Section 8) that "standard threaded discussion support was inappropriate for collaboration," and this because it promoted divergence. This is quite true, but on the other hand standard CMC leaves convergence to the users and this is a basic underpinning of the learning within such systems. When CMC is "well used," users systematically attend to convergence, (using the divergent discussion as a resource) by writing summaries and essays based on the shared material. Would WEBGUIDE confine learner freedom to synthesize/converge because of the complexity of it's complex linking systems… just a doubt.

Response:

While WEBGUIDE'S interface has improved considerably since its first usage, problems remain of trying to think about ideas on a computer monitor. It is still a less convivial environment to play with complexly inter-related ideas than is paper. There is also the difficult trade-off between simplicity and clarity of the interface and the desire to support complicated functionality. The mechanisms to support convergence are only partly automatic, transparent and natural. And yet, if we want to think and write collaboratively then paper will not suffice.

Helen Chappel-Hayios:

Briefly (and I hope not overly simply stated) WEBGUIDE is a tool for organizing text resources around a given subject. It uses a Java meta-structure, linked to archived material. The user defines a personal

perspective and can edit it's shape and content freely. The perspective is physically represented by a "hierarchical tree of information" (Section 8). The user also has access to perspectives defined and controlled by other people and groups in the collaboration, and can call these into the WEBGUIDE interface to examine them. Essentially though, the system supports the building of individual or group perspectives, which users then share (through permissions) within the specific learning community.

It is easy to see how this could be a valuable tool in the Middle School environment for which it was first created and where much of their knowledge construction takes place in classroom discussion (Section 8)... issues of time and complexity apart. From the description given in the article however, I don't see where there is designed space for online collaborative discussion of the sort more familiar in CMC systems. We are told that "users… tended to ignore the perspectives apparatus in favor of engaging in threaded discussions" (Section 8). To do this, despite a possibility that this might have required a fairly convoluted procedure makes one wonder. Does this WEBGUIDE software provide a more straightforward discussion area to be used alongside of the work on perspectives? Have I missed something here?

Somewhere here there seems to be a confusion between a virtual collaborative discussion space and a tool to aid collaborative work. This confusion is also underlined by the convergence/divergence discussion which directly compared this software with standard (doubtful expression) CMC software.

Another point which confused me was the idea of the software as artifact in the same way as a piece of sculpture or a narrative... even if as the author points out, software "represents a very different way of objectifying experience" (Section 7). I'm less certain that we can say this… isn't it possible that the real artifact is the perspective as represented in the interface; i.e., artifact = any one perspective, or the sum of all the perspectives?

A narrative has a plot, characters, suspense, all designed and woven by the storyteller... these are the underlying elements which dictate the shape of the narrative as told. The outward form of the sculpture is similarly dictated by the nature of the materials used, the softness or hardness of the marble, or the type of wood and direction of grain etc. These are the inner structures. Materials selection represents human choices as surely as does software, and they lead to the external

expression. In the same way the software (arguably) leads to an external expression, but here it is in the form of a perspective which appears in the WEBGUIDE interface. I think it matters to examine the metaphor here because it is very central to the problems being discussed.

The artifact or not issue, plays into the question of whether various perspectives can be represented with a single graphical image... the theme maybe; isn't this the total of all perspectives for these purposes? Perhaps Cubist painting rather than sculpture makes a better analogy?

Response:

As detailed in response to Hans below, I have subsequently added a discussion perspective that provides a space for threaded discussion. Previously, threaded discussion took place directly in the comparison perspectives – leading people to ignore their personal perspectives and aggravating the conflict between discussion and construction. One of the hardest things I have had to figure out as a designer is how to integrate this into the perspectives framework, so that ideas entered one place would be available for the rest of the knowledge-building process. I have just now implemented this and have not yet released it to my users. I have still not implemented the sorely needed negotiation procedures. Discussion with Thomas Herrmann and his colleagues in Germany have helped me to understand the issues related to these new perspectives – and why the system should include explicit discussion and negotiation perspectives.

An artifact is never a simple object. A sculpture, for instance, creates a rich world: it not only structures physical space and offers a sensuous surface, it also evokes other objects, meanings and works. Software is yet harder to characterize: what is its form and substance, where are its resistances and affordances? A communication and collaboration artifact like WEBGUIDE makes possible new forms of interaction and knowledge-building – but how do people learn how to take advantage of this without being overloaded? The artifact here is not so much the buttons and windows of the user interface as the discussion content that gets built up through the interface. These issues have led me to another iteration of theory with a seminar in Fall 2000

on how artifacts embody meaning and subsequent analysis of empirical data on how people learn to understand and use meaningful artifacts.

I like the cubist image. But sculptures also encourage and facilitate being viewed from different visual perspectives. I have thought of replacing the mono-perspectival pictures in the paper with video clips that could be run in the JIME publication. Perhaps I could just use animated gifs of each sculpture, that cycle through several views – creating an effect that cubism anticipated before perspectival technology was available.

Helen Chappel-Hayios:

This article does give us a lot of good, clear, qualitative description of the two situations in which this software is being looked at. At some point though, there seems to be a need for firmer ground and a few numbers. Credibility comes from the ability to imagine a situation, doesn't it? It is not just a matter of standard or not methodology; above and beyond that, it is a simple communication issue. And here we have too few specifics in relation to the use.

There are figures that might have been available which could have some meaning, like the number of students, the number of messages which each student posted in an academic year, comparisons between years, ways of showing how fully or otherwise they employed the various perspectives, how much time and training either group was given in understanding this quite complex approach. Any such figures could help one to get a stronger sense of what this experience all might mean for learners and learning. Figures don't tell us a great deal at the depth at which this article takes on the subject, at least not without a great deal of qualification, but they do tell us some concrete things. I would prefer a few more here.

Response:

The middle school classroom had 12 students. During the several months of sporadic usage, 835 notes were entered (including revisions of old notes). This count includes guiding questions and organizing headings that the teacher and I entered.

The graduate seminar had 8 active students. During the semester, 473 notes were entered.

This semester (which is half over as I draft this response), there are 11 active participants. We have entered 497 notes already, but many of these are headings, modifications or entry of data to be shared. This probably represents an average of two entries per week per student. While I work on some technical problems that have arisen, I am not encouraging heavy use of WEBGUIDE. Mostly entries are comments and questions on the class readings, with some follow-on discussion. If I defined some collaborative tasks, we might get much higher usage.

I try to hold class in a computer lab at the beginning of the semester so that we can learn the systems together and students can help each other. Most students can now access WEBGUIDE from home, although this remains problematic. When we all use WEBGUIDE at the same time in the lab, the worst technical problems come up (multi-user issues that are hard to test without class usage). Also, problems of how the entries are organized (how to find what your neighbor just said she put in) and how discussion relates to one's personal perspective. The main beneficiary of class usage of WEBGUIDE is still the designer, who sees what problems need to be solved and what new functionality is desirable. For the students this is a glimpse into the future, but not yet a powerful cognitive and collaborative tool. In each class that uses WEBGUIDE the students participate in reflecting on the process of designing the software artifact – and this is integral to the course curriculum as an experiment in collaborative learning.

Hans van der Meij:

Methodology – teach as you preach. Overall I am fairly positive about this article. The author explicitly defies the traditional path of experimentation/design in set-up of the work itself, as well as in set-up of the article. This is courageous. It also makes for much more interesting reading materials and enhances the author's credibility. With regard to methodology I wholeheartedly agree with the author. I find the notion of "reflection in action" quite valuable and virtually absent in lots of journals. This is a wonderful exception, showing much more of the realities of design where – at least in my experience too – deeper insights often come after-the-fact.

Technical issues. Does the reader get enough action-reflection insights? I think, from a technical point of view, the answer clearly is "Yes". Lots of times I found myself agreeing with choices that, to me, seemed to make sense. Just a few examples: I agree, from a technical point of view it must be vexing to have to rely on an outline display when one wants to visualize different perspectives (and routes, I guess). I agree, the look-and-feel should create a comfort zone for users. I agree, the notion of "inheritance" is useful, especially when I recall all the problems of tagging concepts or notions from several vantage points. I agree, the person is a key factor. Hence, the user can copy, write and rewrite etc. in a personalized workspace and see but not modify other people's work. This also ties in nicely with social rules regarding how to deal with one's own and other people's stuff. I disagree about roles. I see an advantage of being able to see the work of other roles in progress. Figure 2 shows that joining of perspectives takes place way (too) late, namely in Gulch class comparison. It means students are not having enough time to prepare counterarguments and it also means that students miss out on constructing their perspectives along the same lines as that of other groups. In addition, I doubt whether it is desirable to have students think only about their own role or perspective since this is rather unrealistic (I may have this wrong, I am not sure how the system actually was used in practice).

User-based scenarios: use-in-action & reflection. The paper can be strengthened considerably with additional information on user scenarios. Although two usability tests are reported, I miss two issues with regard to the way in which the perspective of the actual user of the system is described: (1) Concrete examples of use in action. The paper is very abstract and technical. The author nicely narrates a design(er) story. I would be very happy if the author could also narrate a user story, including examples of, say, how notes from others are being turning into personalized notes, etc. This would afford us to "see" a little bit of what happens in actual use. (2) More elaborate notions of valued use in action. The user perspective perspires mainly at the end where vital questions of system usability (from the user's perspective) are introduced and briefly discussed. Here, for me, the BIG questions are advanced, the ones that I wondered about while reading. I accept the author's explicit desire to "project a voice which does not redefine the temporality of the experience I am reporting." I also think it is not too late to flesh out some initial answers to these questions in the

closing sections of the paper. In short, I would like the author to substantiate his reflections (e.g., by showing and discussing some how certain "repositories of ideas" have come into being).

Response:

I fear there is still some confusion on how perspectives work. The inheritance diagrammed in Figure 2 takes place continually as notes are added, not just when perspectives are somehow complete. Every user of WEBGUIDE can visit every perspective and read what is there at any time. The restriction is that you can only modify (edit, delete, rearrange) notes in your own perspective. Recently, I have added "private" notes that you can add in any perspective but are only viewable by you. This way, you can annotate any notes in the system privately.

I have also added "discussion" notes that you can add in any perspective; rather than staying in that perspective (and thereby modifying someone else's perspective) the discussion note and the note it is discussing are copied to a new "discussion perspective". The new discussion (and a new negotiation) perspective provides a space for inter-personal discussions to take place. Your contributions in the discussion perspective are also copied into your personal perspective so that you have a complete record of all the ideas you have entered into WEBGUIDE and so that you can integrate these ideas with others in your working perspective.

These changes are part of a rather radical re-design – or at least extension – of the WEBGUIDE perspectives system that has not yet been tried out by users. However, it is worth presenting here in some detail because it shows my response to the worrisome issues that have come up about conflicts between discussion and knowledge building (as discussed especially in point 5 of Section 8 above). It brings the presentation up to date as of Spring 2001.

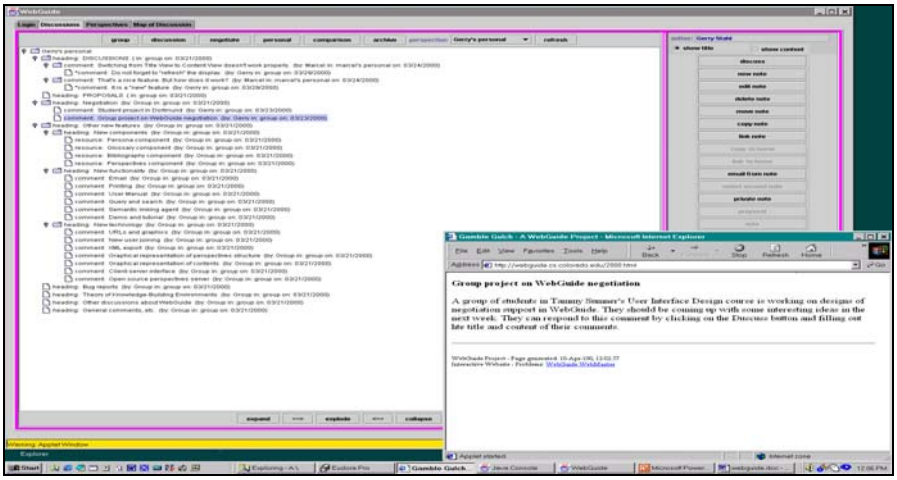

Figure 4. The new interface to WEBGUIDE 2000.

Figure 4 shows the new interface of WebGuide. It now consists of two separate windows, a Java applet interface and an HTML window. Previous interfaces included the HTML window within a fixed size main interface window. The user can now resize and overlap the two windows to optimize and personalize use of screen real estate. The main interface consists on (a) an expandable hierarchy of notes (either their titles or the first line of their content is displayed in the hierarchy – the full content of the currently selected note is displayed in the HTML window), (b) a bar of buttons for selecting a perspective across the top and (c) a control panel of function buttons on the right side.

Figure 5. The new bar of perspectives buttons in WEBGUIDE 2000.

Figure 5 shows a close-up of the perspectives buttons, providing direct access to the most common perspectives and a pull-down list of all defined perspectives in the current database. Note that in addition to the *group* (or class) perspective, the current user's *personal* perspective and the (group or class) *comparison* perspective, there are now perspectives for *discussion*, *negotiation* and *archive*. We will see how these are inter-related in Figure 7 below.

Figure 6 shows a close-up of the function controls, with restricted options grayed-out. The *comment* button allows a user to enter a quick comment below the selected note. The *new note* button is similar to the *comment*, but allows the user to choose a label for the kind of note and to position the new note after (i.e., at the same level of hierarchy) the selected note rather than indented below it (i.e., as a child of it). Subsequent buttons let the user *edit*, *delete*, *move*, *copy* or *link* a selected note. *Copy to home* or *link to home* is used when one has selected a note that is not in one's personal perspective and wants to create a physical or virtual copy of it there. *Email* lets one send an email and have the content of the email and its responses inserted below the selected note. *Search* conducts a simple string text search across all notes (their author, title and content) in the database and displays the resulting notes in the HTML window (where they can be easily printed out). *Private note* is similar to *comment* – except that one can insert it in any perspective and that it will only be displayed when the author is logged in as the current user. *Discuss* and *promote* create notes in the discussion and negotiation perspectives; they will be described in the next paragraph. The *vote*, *website* and *graphic* buttons are for adding votes on negotiation issues, live links to URLs and graphic (multimedia) URLs to be displayed in the HTML

Figure 6. The new knowledge management control panel in WEBGUIDE 2000.

window – these functions are not yet implemented. The *print displayed* button causes all notes whose titles are currently displayed in the hierarchy display to have their content shown in the HTML window for printing. The *print selected* button lets a user select multiple notes in the hierarchy display and have their content displayed in the HTML window. Finally, the *print recent* button displays in the HTML window the content of all notes that were created in the past N days, where N is selected below this button. These search and print buttons are an important step toward providing tools for more effective knowledge management – offering convenient access to selected notes.

How should the *discuss* and *propose* buttons work? A user should be able to start a discussion based on any other user's note found in the system. The resulting discussion should be available to everyone in the group. The two perspectives available to everyone are the group and the comparison perspectives. The comparison perspective quickly becomes over-crowded and confusing, so I decided to create a new discussion perspective derived from the group perspective. Similarly, proposals for negotiations should be able to build on anyone's notes and should be generally available, so I also created a negotiation perspective linked to the group perspective. Recall that the group (or class) perspective contains notes agreed to by the group at large (or seeded by the teacher to provide a shared starting point). The group perspective therefore provides an over-all context for collaborative discussion and negotiation, as well as for individual efforts at knowledge building. So, while we do not want discussion and negotiation notes that have not yet been adopted by the whole group to show up directly in the group perspective (and therefore to be inherited into all other perspectives), we do want to have the discussion and negotiation perspectives inherit from the group perspective so that the group context provides some structure. Moreover, we want the negotiation to inherit from the discussion so that a note in a discussion thread can be proposed for negotiation and so that discussion threads can be viewed in relation to negotiation proposals. As shown in Figure 7, individual personal perspectives should inherit from the group but not from the discussion or negotiation perspectives.

The trick with putting notes in the discussion and negotiation perspectives is to situate them meaningfully in the hierarchy with at least some context. Suppose you have entered a note that I want to comment on and to present for group discussion. Your note is in your personal perspective and I may have found it in the comparison perspective. So I either select your note in the comparison perspective or go to your personal perspective and select it there. I click on the *discuss* button. The system then wants to start a discussion thread in the discussion perspective starting with your note followed by my note. To do this, the system sees what note your note is threaded below in the hierarchy in your personal perspective – let us call that the anchor note. If the anchor note happens to already appear in the discussion perspective (which inherits the whole group perspective), then everything is simple and the system simply makes a copy of your note below the anchor in the discussion perspective and then attaches my note below that. Alternatively, if an ancestor of the anchor in the notes hierarchy appears within the discussion perspective then that closest ancestor is used as the anchor. Otherwise, the system attaches a copy of your note to a special "Discussions" heading note in the discussions perspective and then attaches my note below that. Then we have a

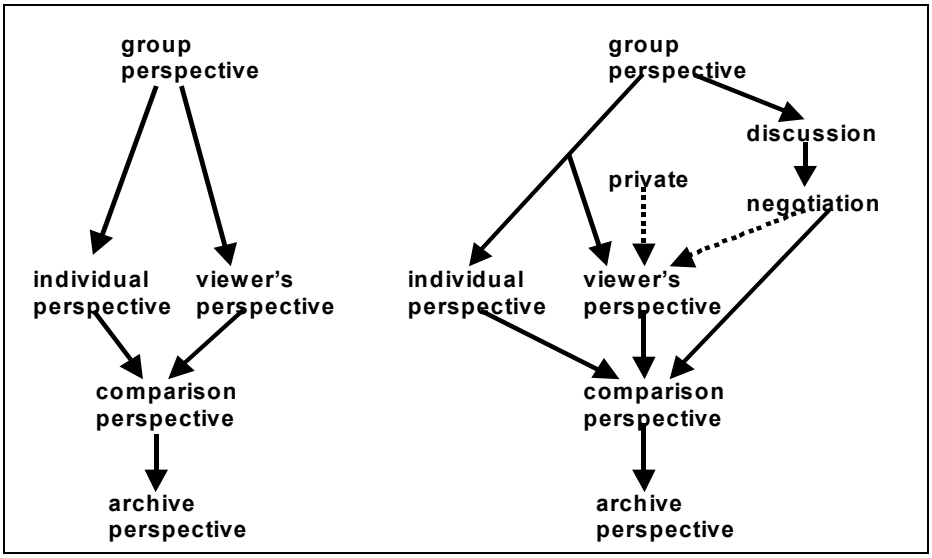

Figure 7. The old inheritance structures for perspectives in WEBGUIDE (on the left) and the new structures (on the right).

discussion thread that anyone can add to in the discussions perspective.

In addition to setting up the new thread in the discussions perspective, the system makes a copy of your note with mine attached to it below the anchor note (which I inherit from the group) in my own personal perspective. This is so that my personal perspective contains all of my contributions to discussions and negotiations. That way, I see all of my ideas and I can conveniently manipulate them in my own workspace. The dotted line in Figure 7 from negotiation to viewer's perspective indicates that these entries will appear in my perspective when I am viewing it.

Similarly, Figure 7 indicates that private notes that I created with the private note button will appear in whatever perspective I created them in when – and only when – I am viewing them. Finally, the archive perspective is simply the group comparison perspective, including notes that have been deleted. This is primarily for the convenience of researchers who want to view old versions of work. Figure 7 shows how the inheritance structure has changed with the recent addition of the discussion, negotiation, private and archive perspectives. The possibility of extending the perspectives metaphor and the underlying computational mechanism to include new perspectives like these confirms the power and generality of the approach.

Figure 8 summarizes the relationships of the buttons and display modes to the different perspectives. The top of the chart ("buttons") indicates the perspectives in which each of the buttons is active (i.e., not grayed out).

modes:	group perspective	discussion (group)	negotiation (group)	personal perspective	other's perspective	comparison perspective	archive (deleted)
buttons:							
discuss		X	X	X	X	X	X
propose			X				
vote			X				
private note	X	X	X	X	X	X	X
new note				X			
edit				X			
delete				X			
move				X			
copy				X			
link				X			
copy home		X	X		X	X	X
link home		X	X		X	X	X
email				X			
search	X	X	X	X	X	X	X
print	X	X	X	X	X	X	X
displays:							
Statement	X	X	X	X	X	X	w. deleted
Discussion		X	X	viewer's	owner's	X	w. deleted
Proposal			X	viewer's	owner's	X	w. deleted
Decision			X	viewer's	owner's	X	w. deleted
Private	viewer's	viewer's	viewer's	viewer's	viewer's	viewer's	viewer's

Figure 8. Table of permissions for WEBGUIDE 2000 buttons and displays.

displayed in each type of perspective (and in some cases to whom it is displayed). Statements are notes created with the *comment* or *new note* button; Discussions are created with the *discuss* button; Proposals with the *propose* button; Decisions with the *vote* button; and Privates with the *private note* button. The viewer is the currently logged in user; the owner is the person to whom the personal perspective belongs.

Yes, this is obviously the designer's story. I think it is premature to give a user's story. For a number of reasons that are my fault (technical problems and poor definition of tasks), WEBGUIDE has been at best used as a threaded discussion forum. I hope that the new structures of Negotiation, Discussion and Private perspectives will help users to engage in personal and group knowledge building. Perhaps then we will see some insightful user scenarios.

Hans van der Meij:

What are the strengths and weaknesses of WEBGUIDE? In Section 3 the author compares WEBGUIDE with other systems. I have two important difficulties here. 1. For me as a reader this is too early, I'm still having a hard time understanding the various ways in which users can work the system. 2. No names of "competitive" others are mentioned. Surely, a true and fair comparison of systems is a rather complex task, well beyond the present paper. So, I do understand the choice that was made. Yet, I could not help asking myself wherein the user might find strengths and weaknesses as they derive from the technical choices that were made. Each system typically affords some processes and outcomes better than others. Often, if not always, this is traded off by weaknesses in other realms of usage and learning. The author could help the reader enormously by offering his insights here because it can advance the discussions about these systems into the theoretically interesting issues of what the system really affords. A comparison invites the author into suggesting which forms and outcomes of knowledge building are best catered for by WEBGUIDE (probably thanks to its x, y, z combination of design choices). The result will be a more refined notion of how design choices impact on usage (as seen by the user rather than technician). The gain is also likely to be theoretical when the author attempts to advance ideas of various types of

knowledge building discourse (I think this can even take place when people build a repository of ideas).

Which perspective? It's not very clear which perspective the author wishes to advance most strongly. Clearly his paper implies that designing requires a multi-disciplinary effort. Although the major part of the paper discusses the technical issues of designing WEBGUIDE, the final part shifts towards arguing in favor of the chosen design methodology and advances some ideas that relate to the user perspective. The latter mean a fairly big shift away from technical issues towards conceptual issues and use in practice.

What design really is? In this respect I think the article is a real gem. I've seen very few studies that have dared to challenge so openly the idea of theory-led designs. All good designs require adaptations as theories typically give guidance only in a very general sense. Gradually as the work evolves, theory is articulated either by reading or by design or both in combination. The author does a fine job in outlining his choice in this respect.

Which ideas led to WEBGUIDE? Obviously, the author has not started to work on WEBGUIDE with zero theory. Unfortunately, the author does not make his starting notions (theory) very clear in the design narrative. I think this is an omission that should be corrected. If I presume correctly, the author has detected some real-life problem for which there was no adequate solution. This triggered WEBGUIDE development. As a reader I would very much like to be informed of what the author considered to be the problem and about his design ideas or philosophy. In that way the reader can "grow" or build knowledge in the same sense as the author intends through (relived) action and reflection.

Response:

As for the competition, I make no claims that WEBGUIDE is superior to other research prototypes or even commercial systems for supporting collaborative learning. It is consciously based on Scardamalia and Bereiter's extensive theoretical, technical and pedagogical work on knowledge-building communities and their CSILE (now KNOWLEDGE FORUM) system that is used in schools around the world. WEBGUIDE's only attempted innovation is perspectives. The idea of perspectives

grows out of my dissertation work with Ray McCall and is based on ideas cited in the paper.

Where did the original impetus for WEBGUIDE itself come from? This is another story, told sketchily elsewhere. While introducing other software in another local middle school, I observed problems of students collecting and retaining website addresses as part of their Web research projects. I thought it would be nice to let them save these addresses on the Web, rather than on harddisks or floppies that never seemed to be available when they needed them. So WEBGUIDE was originally conceived of as their personal guide to the Web, with their collected website links. Then I wanted them to be able to share their links and negotiate class-adopted lists of links. Then I added the idea of annotating and eventually discussing the links, and finally categorizing and reorganizing them. Soon, the superstructure took over and I have still not made it easy to store links in WEBGUIDE. The WEBGUIDE interface has always included an HTML window as well as the Java applet display. The content of notes is displayed in the HTML window – specifically so that website links can be live and one can click on them and go to the site. This also means that graphics and other media can be stored in WEBGUIDE and viewed, and that HTML markup can be used in the content. As for the philosophy behind WEBGUIDE, the notion of perspectives goes back to a former life when I studied Heidegger and hermeneutics, as well as to my more recent (1993a) computer science dissertation that argued for this kind of software perspectives mechanism – warranted by reference to ideas of design theorists Rittel, Alexander, Schön. So persistent questioning pushes the horizon of context further and further back through forgotten cycles of practice and theory, complexly evolving trajectories of inquiry that had no clean starting point *ex nihilo*.

Hans van der Meij:

System underutilization. The problem of system under-utilization is worldwide and well known. Under usage of WEBGUIDE therefore does not surprise. The software industry has yet to find a solution to this vexing problem. There are at least two different types of under usage – inefficiency and ignorance. Inefficiency occurs when people use a rather cumbersome method to achieve a goal. Usually, they follow a

learned (insightful) routine that they never abandon even when better (i.e. faster) alternatives are easy to access (e.g. function keys versus menu choices). Ignorance comes from not knowing that a certain function exists. The problem may be that the user has never had the time to explore the system in any depth, or that the user's knowledge doesn't map onto the design of the system. The mismatch between user knowledge and system design may come from not knowing (recognizing) that the system offers a solution for a problem, or from not seeing how a known method offers a solution to a user problem.

Over-utilization takes place when people spend too much time using technical possibilities to improve what is already good or adequate. A prototypical example is the styling of documents that I see when all the students are asked to do is create a good text. When students should be concentrating on writing a good text, they should not waste time on fancying it up.

Underutilization of a system in its general meaning is not an issue at all. Who cares if people are using "only" about 15% of all the system's options when it affords them to do their job effectively and efficiently? Not me. Underutilization becomes critical only when people do not use functions that impact immediately and importantly on the tasks they must perform. Typically, inefficiency problems hardly ever fall within this category, only the ignorance problems do.

1. Which functionalities that you consider to be key functions did users underutilize? 2. Can you give some examples of troublesome inefficiencies and ignorance of the system? An answer to these questions, as well as to the earlier mentioned point of users scenarios, can make the paper much stronger because they show how design and use interact, which is precisely the point the author tries to make.

Response:

Sure, I do not care if students do not use all the features of WEBGUIDE either – and I do not provide a lot of formatting, etc. in the first place. But I would like to see them get beyond mere threaded discussion – the superficial exchange of off-the-cuff opinions – to deeper collaborative knowledge-building. Seriously taking up each other's ideas and formulations, worrying about terminological disagreements, negotiation of innovative insights that merge multiple perspectives: these would be

exciting to see emerge from the more sophisticated use of WEBGUIDE'S functionality, which allows notes to be modified, copied, rearranged, etc. across perspectives.

Hans van der Meij:

I wondered whether the author has worked in a situation in which there were not enough computers for all students forcing the formation of groups. (This is typical in elementary school.) The group could then be Blake or P4 and operate in the same way as Blake, except for the fact that the group has many members (up to 4 or 5). This would pose another challenge to the system.

Response:

Periodically, students have teamed up on computers. This is nice for collaboratively learning how to use the system. It is also useful if I want to videotape the usage and analyze the discourse within the little group for a fine-grained view of what is going on from the user perspective. The problem with doing this with WEBGUIDE is that it is so text-based and only one person can type text into the shared computer at a time.

Hans van der Meij:

Perspectives? I am still struggling with the notion of perspectives. For example, the definition of perspectives simply is another section named "xxx perspectives." And how should I fit in the notion of 'role' (e.g. that of landowner) within the typology of literal, figurative and computational (Section 3). And what should I think about different points of view within roles? Are these perspectives too (as seen from the designer's point of view)? And what about class perspective, team perspective?

Response:

The perspectives mechanism of automatic inheritance of content down the hierarchy is very general. In some cases I have used it to define a hierarchy of domain knowledge (my dissertation), of roles (the middle school Gulch project), of academic disciplines (the interdisciplinary seminar), or just of different people (this semester). The group or class perspective is supposed to display the state of knowledge that has been mutually agreed upon, and thus requires the still-missing negotiation support. So now it contains mostly what the teacher has defined by fiat as the shared knowledge structure in order to get the process going in an organized way. Yes, this is all hard to explain or comprehend, especially without actually using the system.

Gary Boyd:

1 AN ILLUMINATIVE LEVELS REVIEW

The approach I am taking in this review is based on my theory of nine cybersystemic emergent levels of interaction and values (Boyd, 1997).

2 GLOBAL DISCUSSION AND APPRAISAL (in terms of the nine highest cybersystemic emergent levels' requisite-variety value criteria).

2.1 The paper and venture are both Good at the 'Symviability-hope inducing' highest ontological level:

The highest evolutionarily emergent level is that of eco-co-cultural symbioses. The form of requisite variety required is whatever is plausibly hopeful towards such symbioses.

Overall "WEBGUIDE" is a really good, i.e. eco-co-culturally hopeful, form of Web-based learning support. The kind of CMC/CSCL knowledge construction support which Stahl and associates are developing is certain to be hope-sustaining (the highest good) for groups of people who need to learn together, and for persons who wish to adaptively select what they choose to learn/construct and what they choose to teach / help others construct. In short Stahl's venture is a good strategic direction for Webucational technology to take. In contra-

distinction to bad directions, such as behaviorist CBT, which create dependencies, or such as competitive instructional games which reinforce opportunistic individualism.

It is of course a hopeful venture for those of us in the CSCL R&D profession at large (e.g. the JIME audience) and those in graduate seminars such as the one held as part of the project.

It is also ecologically hopeful in this particular case where the Logan school test venture brings together stakeholders' and experts' perspectives to seek to co-construct understandings about workable solutions to the heavy-metal water pollution from Colorado gold-mine tailings problem.

2.2 Progressive at the 'Scientosophic' (scientific methodology) level

2.2.1 Methodological contributions

There are two appreciable scientific contributions being made; one methodological, and one substantive.

The main methodological contribution is the departure from both conventional experimental work, and conventional case study, made possible by combining the narrative research approach of (e.g.) Bruner, and the reflective practitioner praxis approach of (e.g.) Schön. The WEBGUIDE groupware greatly facilitates this participatory and reflective research method by recording and re-ordering transactions. This is the case however only insofar as learners and teachers can be supported and persuaded to work through it. If the research and development team were to use a parallel instance of WEBGUIDE themselves for their own work even better research possibilities could emerge.

Although the reflective praxis narrative methodology is a real advance over empirical experimental methods, it still reaches only halfway from conventional empiricism toward Critical Realist scientific methodology (arguably the best currently available; Bhaskar et al. at CCR@criticalrealism.demon.co.uk). Critical realist science insists on trying to build (preferably executable) models of the real underlying polycausal mechanisms which give rise to whatever can actually be observed. The drawback of Critical Realist scientific methodology is that for social and psycho-social systems it seems that it can be applied only *a posteriori*. This is because to attempt to apply it as part of praxis leads to paradoxical changes in the system's/person's actions being studied, including the researchers'!

2.2.2 Applicable Theory?

Stahl writes in Section 7, Theory in Practice, "This led us to look for a theory of computer mediation – and for that matter for a theory of collaborative learning…. Of course it turned out that there are no adequate theories on these topics." 'Adequate' is left undefined. From the critical realist perspective an adequate theory is one which enables the construction of a model of the underlying generative processes which yields a good explanation of what happened, and possibly even predictions of what is likely to happen if the work is continued. There are a few quite interesting theories available which alone or combined might become adequate:

With respect to the computer mediation of educative human interaction, Terry Winograd's Coordination Theory (197X), Mildred Shaw's (198X) computer mediated collaborative extension of George Kelly's personal construct theory, and Gordon Pask's (1975) Conversation Theory - particularly as extended by Shiela Harri-Augstein and Laurie Thomas (1991) Learning Conversations, are what come to mind immediately. Then there is Snow, Corno & Jackson (1997) on the overlap between cognition and conation. Also recent work by Chi, Resnick, and Jacobsen.

With respect to the collaborative learning processes, although Habermas is mentioned by Stahl, his theoretical prescription for conducting non-dominative discourse to legitimately promote understanding (Habermas,1984-7) which deals directly with the issue of conflict implicit in collaborative learning was missed. Then again Gordon Pask's Conversation Theory deals with collaborative distributed cognition learning in terms of conversation among inter-M-individual 'p-individuals' (vid. Scott, 2000). One might also usefully employ Kenneth J. Gergen's social constructionism theory. See his (1994) Realities & Relationships book. Then there is the interesting treatment of collaborative learning by Panitz (1996) on his website.

None of the above handle motivation really well. Keller's ARCS theory is workable in practice but not very profound. Ryan and Deci's (1999) Self-determination theory is more profound and still useful. My own motivation theory (The Ought That Is - vid. Boyd (2000)) is an extension of the biologically evolved meme-complex propagation imperative (Lynch, 1998) which is preemptive and universal, but the under-laboring required to unite it with collaborative learning conversation theory has not alas yet been done.

In some sense then perhaps there is indeed as yet no simply usably "adequate" integrated theory of computer/communications mediated WWW collaborative learning.

2.2.3 Substantive contributions to knowledge

The main substantive contributions to practical scientific knowledge are still apparently tentative: to wit that knowledge co-construction by learners can (perhaps) be guided by appropriate multiple-perspective Web-based groupware, and that collaborative learning can be facilitated by the types of multiple perspective workspaces with automatic 'computational' inheritance linking among objects in various spaces. Both these results remain tentative confirmations due to the various logistical, social and technical difficulties which have arisen, and which have constrained and reduced on-line participation. It is however, to be expected that as such difficulties are overcome more definitive narrative results will soon be forthcoming.

2.3 Good value at the 'Emancipative level' (liberating from both 'task robots' and 'learning robots').

As a pre-requisite to scientific thinking it is necessary to release one another from habitual ways of thinking and of learning, what Harri-Augstein and Thomas call 'task robots' and 'learning robots' or what Pask calls 'cognitive fixity' or more recently fashionable as 'limiting ontological beliefs' (Chi et. al. 1994).

WEBGUIDE appears to be promising groupware to support new ways of carrying out knowledge construction tasks and developing the kinds of metacognition which enable replacement of inappropriate learning strategies. This is so because of the direct juxtaposition provided by the multiple "perspectives" windows between various learners' and teams' ways of dealing with the domain problems. Different strategies for choosing and evaluating sources and facts and discussions about them are directly exhibited to all.

2.4 At the identity conjugative-propagative (The Ought That Is) level the paper is quite interesting. (The actual examples involve cloning teacher & mentor identity-memeplex chunks?)

Stahl's WEBGUIDE paper is of course an example of his propagating part of his own identity (qua researcher) meme-complex, and I think it will be successful in finding others to acquire and re-propagate this

narrative reflective praxis approach as part of their researcher-identities (not just superficially).

The WEBGUIDE environment itself offers teachers and pupils good opportunities to acquire, construct and propagate parts of their meme-plex identities. The so-called 'class perspective' provided by the teacher to start the class off being a case in point. (It probably should be called "teacher perspective" or "Seed Perspective" since the class did not construct it. If all goes well substantial parts of it, and similarly other parts contributed by the expert mentors, will be re-constructively cloned into the student and team perspectives – becoming parts of their individual and collective human identities.

2.5 Moderately Good at the Negotiative level (Almost adequate funding seems to have been obtained, and the need to negotiate development goals among R&D project stakeholders is recognized and operationalized.

With respect to pupils the intention to support negotiation in knowledge construction is there. The basic aspiration behind WEBGUIDE is one of promoting negotiation among points of view. In section 1 we read "… designers often create an evolving design artifact from alternative technical points of view; different designers have different personal concerns and styles, requiring considerations based upon access to different rules of thumb, rationales, constraints, standards and other forms of domain knowledge."

These sorts of important interpretive perspectives were apparently supported in the development of WEBGUIDE. They are also supported by WEBGUIDE for the learners who are designer/constructors of their own knowledge. There is therefore now the possibility of using a version of WEBGUIDE in bootstrapping fashion as Computer Aided Software Engineering groupware for designing new versions of itself.

From a negotiative standpoint the main weakness is the assumption that the important thing is to provide "good-openings" (see Orrin Klapp), without equal emphasis on the also necessary "good closings". Each participant needs a really PRIVATE personal perspective space (to try re-arranging her hand in without embarrassing oversight). There is also need for private side communications to form coalitions etc. within WEBGUIDE. As it is, one gathers that e-mail and other modes of communication were used a lot. In general the Backstage vs. Frontstage is important for all the classes of perspectives. For negotiating

resources and reputation, the whole class perspective might well have a fontstage version open to anyone on the WWW.

At first sight it appears that adequate financial, human and situational resources were negotiated for developing WEBGUIDE. This is partly because of the pathetically low funding which is the general norm for educational research. Under scrutiny, only the human (researchers, software engineers, teachers, mentor-experts) resources seem adequate. However with more ample funding all learners could have been provided with state of the art large-screen laptops and high-speed cable access so that they could have used WEBGUIDE from home at convenient times. That would also involve more negotiation with parents etc. With better negotiation of situational resources and protocols the break-down of CSCL into ordinary F-2-F classroom work might have been avoided. That activity in turn could also have been facilitated by a larger research budget.

2.6 Only weak use of viral information/memes was made via WEBGUIDE.

The name 'WEBGUIDE' is a nice bit of viral information (meme) in itself. Perhaps the generic form should be 'WEBGUIDE' and this one be trade-marked as 'WEBGUIDE (tm)' if that has not already been done. The interface screen design seems reasonably memorable, although compared with that of e.g. 'The Brain (tm)' not very sexy for school youth.

The main weaknesses at the memetic level seem to be:

a) that the chunks chosen are "notes" whereas the real chunks of a knowledge construction conversation, particularly of threaded discourses which seemed to be what were occurring spontaneously in the WEBGUIDE ventures, are "repartee chunks." Short exchanges of information query and response which confirm structures or mark new distinctions (vid. Pask's CT). Attempts to analyze CSCL using single messages have not worked out, because the single message is usually not the important executing semantic unit. (vid. Claude Ricardi-Rigault NOMINO TELUQ). So it should be possible to have linking and inheritance of 'repartee-chunk' objects not just notes.

b) Visual diagrams, pictures, and audio speech/sounds, and video clips, are very memorable and informative, and should ideally be provided for, if this has not already been done.

2.7 Good at the 'Sustenantial information level' (info-resources, mentors, help).

The use of the cross disciplinary graduate seminar working in WEBGUIDE to explore theoretical perspectives and also to reflexively improve WEBGUIDE is an excellent sustenantial aspect of this whole project. At the Logan School also, sustenantial resources and multiple 'perspectives' were made available to pupils and teachers which otherwise would not have been available to them.

An important question is: Are objects from the WWW directly importable into WEBGUIDE? I did not notice examples of imports from the Web, but maybe this is possible? However some kinds of obviously sustenantial objects for knowledge construction do not appear to be deployable within WEBGUIDE. Directed-graphs and their matrix duals, and various executable objects such as spreadsheets, MathCad worksheets, Stella models etc. should be held and linked in the object bases of future WEBGUIDES.

The somewhat odd use of the term 'perspective' for a socially (person, team, class) owned workspace is nicely rationalized, and so I guess it is OK.

I do object however to the peculiar use of the (normally mathematical) term 'computational perspective' - here used to mean merely inheritance linked text objects. Would not something like 'auto-linked perspectives' do better?

2.8 Fair at the Deterministic Automata Level (computer application, server & telecomms levels).

The questionably adequate DB/object-base system, Web client-server task-partitioning problems, and severe view-space design limitations, constrain functionality due to limited availability of state-of-the art hardware & communications for pupils etc.

3 CANONICAL REPRESENTATION & VIEWS

3.1 Available Survey of other Web tools for learning support.

An excellent survey being done by the BC Institute of Technology, and supported by the Canadian and British Columbia Governments is currently in progress and is available at http://www.ctt.bc.ca/landonline/evalapps.html.

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Response:

I found the JIME reviews very heartening. The reviewers clearly understood and appreciated what I was trying to do with my narrative approach to reporting on recent research. Furthermore, they added important critical perspectives – particularly the preceding six page commentary by Gary Boyd. I feel that my concluding response to the reviews should consist of a brief overview of the adventure of composing this paper.

The paper grew out of a submission to AERA '99 (the annual conference of the American Educational Research Association in Montreal). To have a paper accepted to this conference, one simply submits an abstract. When my abstract was accepted, I felt free to write in whatever vein I chose. The freedom from having to write to

traditional reviewers with narrow paradigms of scholarly publication allowed me to experiment stylistically as well as to think about what format would be most appropriate to the level of experience with WEBGUIDE that I wanted to report.

The paper session at AERA was coordinated by Ricki Goldman-Segall, who served as the discussant as well. I had just read her book, which has a "thick description" style of interwoven themes and which precedes each chapter with one of her photographs. This gave me the impetus to tell my story by talking about the diverse themes which were important to me. I also decided to introduce a decorative element to the page like Ricki did, and to tie my sculpture loosely to my content.

It was clear to me that providing a traditional analysis of the software usage would have been wildly premature. While the use of WEBGUIDE by one teacher and his dozen students over several months had made a number of technical and social issues painfully clear to me and while the experience had been an experience for the students, there was nothing entered into the database to illustrate the ultimate vision I had for the software approach. Similarly, in my graduate seminar with about eight students for a semester, WEBGUIDE served more as an example of what we were thinking about than as a tool that let us think about it more deeply. What was interesting was not the empirical data about the software usage, but the process ("dance," "structural coupling") by which our understanding of what was needed developed in the classroom settings where a crude version of WEBGUIDE was used.

The work on WEBGUIDE continues to be the focus of my activities. Many of the weaknesses pointed out in the reviews are being gradually addressed in new software functions, theoretical papers, and funding proposals. This evolving article remains my fullest discussion of perspectives and their inheritance, a topic that is devilishly hard to explain clearly. WEBGUIDE 2000 is now being used in my seminar on CSCL. Every month I produce a new version with additional improvements. However, while some students are starting to use it regularly to formulate and discuss ideas, its use still falls far short of the goal.

It has become clearer to me that WEBGUIDE needs to be a *collaborative knowledge management environment*. It needs to better support the browsing, modifying, and re-organizing of inter-related ideas. "Knowledge-building" has become a more central concept for

me and I am trying to understand how it proceeds or could proceed: what activities are involved and what tools could support these interpersonal activities. Talking about knowledge-building (a concept I attribute to Carl Bereiter) seems to be a productive way to think about learning in a social and collaborative framework. The subtle intertwining of group and personal perspectives is a central structure of collaborative knowledge building.

The notion of "artifacts" has become ever more central to my theoretical interests. My seminar this semester is on the question of how artifacts – particularly computer-based artifacts like WEBGUIDE – affect our cognitive abilities. How do artifacts embody meaning and how do people design that meaning in to them and how do others learn what that meaning is? What are the implications for designing new media to support thinking and collaborating? This week we are reading Heidegger's discussion of how works of art (like my sculptures?) not only make explicitly visible their forms, meanings and material, but actually open up whole new worlds in which human activities can take place. What kind of world do we want to create for future WEBGUIDE users? What kinds of intellectual worlds do we want students to collaboratively construct for themselves?

The problems of getting communities of students to adopt Web media like WEBGUIDE are daunting. Look at our use of the JIME technology. None of the reviewers knew how to use it effectively. They probably first typed up typical reviews in their word processors and then pasted them into the top of the discussion hierarchy. Then they broke them up and stuck some pieces under different headings, but never in the places that were linked to article sections. Then, months later, the author had to respond in a similar way. The editor of the reviews did not even post his thoughtful contributions to JIME at first, but emailed them separately. The idea that the JIME medium might support a back-and-forth knowledge-building discussion among the reviewers and with the author – grounded in the artifact of the submitted article, section by section – was not realized. Unfortunately, this is typical not only of JIME and WEBGUIDE, but more generally. These are the pressing issues that need to be discussed at this stage, more than details of technology and statistical assessment methodology.

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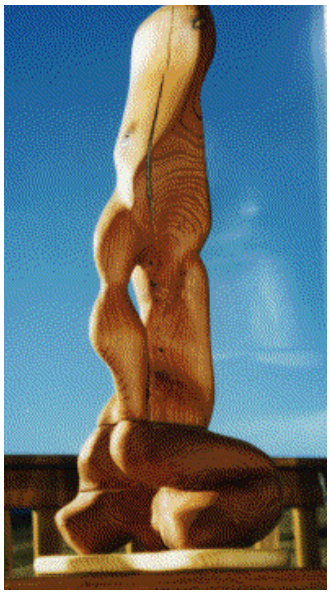

This paper grew out of the author's *Readings and Research in Cognitive Science* seminar, Spring 1999, on "Computer Mediation of Collaborative Learning", with the following participants: Kirstin Butcher, John Caron, Gabe Johnson, Elizabeth Lenell, Scott Long, Rogerio dePaula, Paul Prestopnik, Tammy Sumner. The WEBGUIDE research is a collaboration of the author with Rogerio dePaula and other L^{3}D members, Ted Habermann and his group at NOAA, Dan Kowal and his middle school students, the participants in my WEBGUIDE seminars, Thomas Herrmann and his group at Dortmund, and the researchers in the ICS "Articulate Learners" project.

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