Between Information and Communication: Middle Spaces in Computer Media for Learning

Christopher M. Hoadley

Center for Technology in Learning; SRI International

Noel Enyedy

Education in Math, Science, and Technology; University of California, Berkeley

Abstract

In this paper, we identify two categories of media that are common in computer-supported collaborative learning and software in general: communication media, and information media. These two types of media map easily on to two types of social activities in which learning is grounded: dialogue and monologue. Drawing on literature in learning theory, we suggest the need for interfaces that help students transition from dialogue to monologue and back again. This "middle space" between communication and information interfaces is illustrated with several examples from CSCL. We advocate filling in this middle space with software and activities that transcend some of the traditional design tradeoffs associated with information and communication interfaces.

Keywords: Collaboration, Interaction & Design Tradeoffs

Introduction: computers, communication & learning

Computer mediated acts of communication are becoming more commonplace in today's classroom. Like all media, particular computer technologies tend to support and encourage particular genres of communication, interaction and collaboration. Sometimes computer mediated interaction replicates genres found in non-computer-based media, such as the face-to-face conversations, telephone calls or reading and writing books. However, computer based media also support new genres of interaction and communication that do not directly map on to previous genres of media.

To better understand computer-supported collaborative learning and design more effective tools to support computer-mediated interaction, we must understand both the ways in which media constrains and enables certain types of interaction and also the process by which people are able to construct and negotiate meaning through interaction and collaborative activity. In this paper, we begin with the assumption that all computer-based media are to some extent communicative, interactive and collaborative, since all media presumes some sort of audience, even if the audience is oneself (Eco, 1994). Based on this assumption, we examine the different models of collaboration that are supported by different computer technologies and how they structure interaction. As a starting point, we examine some asynchronous collaboration tools which are used in educational settings. To understand the interconnections between social interaction and student learning, we examine these tools through the lens of theories that examine the social origins of learning (Vygotsky, 1978; Wertsch, 1985). While we recognize the importance of an individualistic perspective on learning, we limit our discussion of learning theories to the

perspective that accounts for learning as a product of social interaction, as this seems particularly well adapted to our concerns about the design of computer-supported collaborative learning.

Specifically, we describe two types of computer-based media genres: information genres and communication genres. We then examine an interesting parallelism between these two types of technologies and theoretical notions about collaborative learning and social appropriation of knowledge. Finally, we advocate abandoning the false dichotomy between two genres of collaboration tools and provide examples of productive CSCL tools that begin to fill out the "middle spaces" between information and communication.

Interface design: from information to communication

In this section, we describe two stereotypically different types of computer media: information interfaces and communication interfaces. These types of interfaces differ in the primary goals that drive their design (and as a result differ in the types of activities in which they are used). Information interfaces are designed primarily around individual access, manipulation, synthesis and analysis of information. While these tools may provide the means to share information among many people, the focus is on how individuals may be supported in their interactions with information. In contrast, communication interfaces are designed to support interactions between people (generally communication between small groups). Information interfaces might be thought of as functional extensions of libraries and filing cabinets. Communication interfaces are often viewed as extensions of messaging systems, such as postal mail or telephones.

Generally, these two types of interfaces are seen as qualitatively different. A number of researchers have pointed out the differences in design constraints for "groupware" interfaces as opposed to more individual information interfaces (Grudin, 1994; Winograd, 1988; Winograd, 1989). Information interfaces tend to be data-centric, meaning they take much of their structure from the form of the information they contain. For instance, a computer-aided design tool is highly specialized to represent abstracted three dimensional data, while calendar management software is highly specialized for representing appointments, lists of tasks to do, and the like. Information interfaces often deal with issues of search and retrieval, or perhaps information presentation and visualization. They rarely present socially relevant representations (i.e., explicit social cues), such as contextual information about other people using the system or discursive markers (Hoadley, 1999; Hoadley, Hsi, & Berman, 1995b). Information interfaces also tend to be more context-independent, presenting information intended toward any user. In contrast, communication interfaces tend to be more domain-general and process-focused. They take their form more from interaction processes than from the content of the domain, often striving for verisimilitude to offline interactions, such as face-to-face discourse or group work. These systems frequently include explicit support for social features such as authorship, privacy, and turn taking. These interfaces tend to present information that is highly contextualized. For instance, an e-mail message might make sense only to its intended audience, the addressees, in the context of an assumed shared understanding of the particular topic, history, norms and vocabulary of the electronic conversation.

These two types of systems rarely overlap, and in fact there has been some recent controversy over which type of design is "better". For example, a special issue of the human-computer interaction journal "interactions" (Shneiderman & Maes, 1997) was recently devoted to a debate on whether the future of interface design lies with direct-manipulation interfaces (data-centric,

domain-specific, and more context-independent) or with agent-based interfaces (process-oriented, socially contextualized, full of socially relevant representations). As we will discuss below, both types of interfaces have a place in learning, and some new tools exemplify how to bridge between these two perspectives in interface design. First, we examine some theories of communication and learning, and then we readdress these two types of interface design and their role in CSCL.

A Continuum of Models of Collaboration: from Dialogue to Monologue

One way to frame the design of CSCL environments is by the types of social interaction and communication they support. This section argues that based on socio-cognitive theories of learning different forms of participation lead to different learning outcomes. We start by outlining some of the differences between two models of collaboration– dialogue and monologue– that occupy different ends of the spectrum along the continuum of ways of communicating. Next, we examine some of the educational implications for each model. Finally, we end this section by arguing that both types of interaction are important for CSCL. However, rather than attempting to support one type or the other, we should be designing solutions that support the type of social interaction that is appropriate to where the students are along their learning trajectory as well as the transition between types of interaction.

A striking parallel exists between these different genres of interfaces and media, and the traditional distinction in social learning theory between the activities of monologue and dialogue. Vygotskian social learning theory proposes that learning occurs as a result of first participating in activities with others who scaffold the process, then internalizing and appropriating skills which allow the novice to become more expert. (Wertsch, 1985). Yakubinskii, a contemporary of Vygotsky's, highlighted the distinction between monologue and dialogue as forms of social interaction, and suggested that learning through social appropriation involved moving from dialogic performance to monologic performance (Yakubinskii, 1923/Wertsch, 1985). According to Yakubinskii, the critical factor in determining what is monologue and what is dialogue is not the number of participants involved. Even a monologue theoretically involves both a speaker and a listener. Rather, the critical factor that distinguishes a dialogue from a monologue is the degree to which the interlocutors actively participate in the production of the text and its meaning within a concrete speech setting (Yakubinskii, 1923/Wertsch, 1985). In this manner, dialogue is interaction in which participation is distributed across individuals, while in monologue, the production of speech and meaning is reserved for only a subset of the parties involved. Monologue, then, shares many of the features of information-centric media: more context-independent (i.e. assumes a limited role of the context in establishing the meaning of the text), lack of social cues, and a focus on the domain and not on interaction. Dialogue, on the other hand, shares many of the features of communication media, with a more distributed locus of control, more inclusive participation, and a focus on interaction and co-construction of meaning.

Tools designed to facilitate monologues lead to dramatically different participation structures and interactions than the tools that are designed to facilitate dialogue. In addition, the two types of tools make differential assumptions about the nature of "meaning" and how it is created and communicated. This is important because the affordances and constraints of these tools reflect epistemological assumptions about the nature of meaning and the nature of participating in a community of practice. These assumptions may be communicated to students when they interact

with the tools. In science education, where learning involves developing models, theories and explanations and not just the memorization of facts and (National Academy of Sciences - National Research Council, 1996), it is important for students foster an epistemological approach towards science learning as "science in the making" rather than as "ready made science(Latour, 1987). Learning science by rote—by consuming monologues—encourages students to think of scientists as doing the same (Linn & Songer, 1993). In this case, the use of a particular tool or participation in a particular style of interaction during the process of learning might influence how students think about the nature of that domain.

How do the differences between monologue and dialogue affect student learning? To begin with, monologue's extended turns privilege one speaker at the expense of the others. Many studies have documented how the rights and responsibilities of interlocutors established within a speech setting translate into different learning outcomes for the students. For example, the infamous Initiate-Respond-Evaluate (IRE) participation structure limits students' contributions to answering simple questions with known responses followed by an evaluation of their response by the teacher. This lack of collaboration in the production of the interaction's meaning places IRE interactions on the monologue end of our continuum. Many analyses of the IRE participation structure have suggested that it leads students to perceive that learning consists of memorizing a set of predetermined, non-negotiable facts (e.g. Edwards & Westgate, 1987). These are exactly the types of epistemological assumptions that are at odds with students engaging in sensemaking activities around phenomena that lead to deep conceptual understanding—modelling, theorizing and (National Academy of Sciences - National Research Council, 1996).

Further, the two styles of collaboration reflect different assumptions about the nature of meaning. The message of a monologue is not debated, nor negotiated during its production. In monologue, meaning is not seen as the product of interaction but the expression of one person's ordering of experience (Coutler, 1999). As Bahktin put it, "with a monologic approach (in its extreme or pure form) another person remains wholly and merely an object of consciousness, and not another consciousness," (1963/1984). Because monologue is based on the private ordering of experience to be communicated in the absence of a shared communicative context, it requires the text to be maximally explicit in its linguistic formulation. Monologic forms of communication assume that the objective semantics of the message itself are adequate to convey the text's meaning, and they do not provide a means for refining or extending this meaning. From this perspective, one can see that relying solely on monologic forms of collaboration embodied in informational reproduces many of the faults and limitations of the much criticized transmission model of communication and instruction (Pea, 1993).

Yet, monologic forms have some important advantages. Monologic forms are the hallmark of individual competence and accountability, and are one of the primary measures of expertise in learning assessment. Student monologues such as essays or test responses are used to judge students' competence and are often used to identify experts long after formal schooling. Monologues often reach larger audiences precisely because they are less contextualized. The explicitness of monologic expression represents a significant intellectual challenge, and the value of concise and concrete expression of one's ideas for one's own learning has been well documented in the psychology (Chi, de Leeuw, Chiu, & LaVancher, 1991; Chi, de Leeuw, Chiu, & LaVancher, 1994). It should be noted that this benefit occurs in participation in the *production*

of monologue; while "consuming" monologues (e.g., reading textbooks, hearing lectures) is probably the most common learning activity in modern schooling, it has been ceaselessly demonstrated to be ineffective compared to more engaged forms of learning in which students take a more active role.

In contrast, dialogic forms of communication stress that the meaning of a message is negotiated in interaction and only partly determined by its semantics. Research that has looked closely at the talk and actions of people engaged in purposeful activity have noted some of the ways which people interactively create and negotiate the meaning of an exchange out of the ambiguous, indexical, and implicit public contributions of the interlocutors (e.g. Goodwin, 1995; Hall & Stevens, 1995). A particularly telling example relates how a family could continue to communicate with their father after his stroke reduced his vocabulary to three words: "yes," "no," and "and" (Goodwin, 1995). Goodwin's analysis demonstrates that even though the father could no longer make any original, explicit semantic contributions, he remained an active and full participant in the family's discussions. In cases such as these it become clear that meaning is not objectively and explicitly contained in the explicit semantic content of isolated speakers, but instead created through the negotiations that span the different participants (Goodwin, 1995). Dialogic, communication tools facilitate this on-going, contextualized process of meaning making which is more closely aligned with the epistemological assumptions about the constructive nature of learning.

Vygotsky also argued that monologue evolves from dialogue, claiming that, "monologue is a higher, more complicated form of speech," (1978). One implication of considering both the theories of social appropriation and the research on conversational analysis is that in the early stages of students' learning trajectories, dialogic speech and the tools designed to support it may, in fact, be more valuable than their monologic counterparts. Two qualities of dialogic speech seem especially fitted for the early stages of a student's participation within a domain of practice. First, because dialogic speech occurs within a shared communicative context requiring less explicit linguistic formulation, students may find it easier to articulate their emerging understanding of the domain. Publicly articulating and "making visible" one's initial and emerging understanding is a critical aspect of active learning (Bell, 1997; Enyedy, Vahey, & Gifford, 1997; Koschmann, Myers, Feltovich, & Barrows, 1994). Second, once a student's thinking is made "visible" it is available to others for comment, criticism and negotiation. Dialogic interaction allows for interlocutors to give each other timely feedback on each others ideas leading to the iterative refinement of partial meanings and the construction of increasingly sophisticated approximations of scientific concepts (Roschelle, 1992). On the other hand, monologic communication provides a more ordered presentation of the information and can be particularly persuasive and helpful when the goal is to establish a consensus.

Thus, participation in both monologue and dialogue are valuable parts of the learning experience. If we take social appropriation seriously, we must acknowledge that the social scaffolding of dialogue may preceed expert monologic performance. In addition, dialogue conveys the values and epistemology of active construction of knowledge. Yet, students must move towards monologic forms to demonstrate competence and ultimately to participate fully in an expert community. What does this suggest for the use of information and communication interfaces?

Learning is not a single, monolithic event, but is comprised of a series of separate, interrelated activities. This implies that a learning trajectory is likely to include a number of different

contexts, some of which may be best supported by dialogic, communication interfaces and some of which may best be supported by monologic, informational interfaces. The point is to endeavor to offer the right tool to the student at the right time along the student's learning trajectory. Better still, if we develop tools that fill out the "middle spaces" of the continuum, that offer more structured dialogues, more open monologues, and ways to quickly move back and forth between different modes of collaboration, students will be able to use the tools in a manner supportive of their learning wherever they happen to be in their learning trajectory at the moment.

The Challenge: Re-framing past tradeoffs

As we noted above, computer media genres have tended to be either information-centric or communication-centric. Some of the design tradeoffs between information and communication interfaces that have traditionally existed can be re-framed and re-examined in light of the continuum of collaboration styles. These tradeoffs include centralized and widely disseminated documents vs. decentralized but narrowly disseminated communications; reflectiveness vs. interactiveness; and temporal coherence vs. topical coherence. First, we elaborate on these tradeoffs as they have existed in the past. In the following section, we describe how advances in CSCL permit us to transcend some of these limitations.

Inclusion Vs Centralization

Traditionally, mass media have been highly centralized, with reproduction cost entailing a clear tradeoff between wide dissemination and more inclusive, open authorship. Textbooks are widely disseminated but highly centralized in authorship, while student reports are easily produced by anyone but narrowly shared. This creates a sharp boundary between "real" authors or publishers and amateurs or novices. Information interfaces are often more centralized but less inclusive, while communication interfaces by nature make everyone an "author," but they generally do not generate replicable products which may be disseminated widely.

Reflective Vs Interactive

One dimension traditionally mentioned in the design of groupware is that of time scale. Traditionally, monolithic, monologue-like information media proceed at a very protracted time scale. For instance, it would take months or years between turns if someone published a book on a subject, and this was to be addressed by a rebuttal in another book. Even the delay between authoring a web-page and the time when it is read or interpreted by the intended audience is long compared to the time between exchanges in communication-like media. Communication media such as telephones and chat systems proceed at a very brisk pace, with exchanges taking on the order of seconds. With the increased interactivity, the time available for reflection decreases. Furthermore, fast media genres are likely to be more ephemeral, further decreasing opportunities for reflective learning.

Topical vs. discursive coherence

Communication tends to follow the Gricean maxim of coherence (Grice, 1968), in which each comment is relevant to the previous utterance and the presumed discursive goals of the participants. Comments follow one after another with a discursive coherence that rests on the shared communicative context being established throughout the interaction. Most communication media help establish and maintain this kind of discursive coherence. On the other

hand, information media tend to have more topical, but less discursive, coherence. Think, for instance, of articles within a particular journal. While articles within the journal address similar topics and may reference other articles, except for special issues, one article does not directly respond to another article. In general, each article is organized topically around the argument it presents. Most interfaces follow one of these two patterns, discursive coherence or topical coherence.

The tradeoff between Convergence and Divergence

A traditional tradeoff related to our discussion of when a tool is valuable, is the tradeoff between convergent and divergent activities. Divergent activities such as brainstorming are highly generative but do not tend to yield unified products. Convergent activities such as reaching a consensus or creating a policy document yield concrete outcomes, but may not allow for wide participation or inclusiveness of ideas. In a business setting, these activities are explicitly alternated, with a facilitator ensuring that the products of a brainstorm are revisited when it comes time to make a decision. In school settings, dialogic activities in which students articulate their emerging understandings have been portrayed as being very divergent, with few concrete outcomes. Activities that are seen as convergent, such as a class discussion that is tightly managed by the teacher to arrive at the normative answer, often exclude some students' views. Student tools for communication have tended to produce divergence. On the other extreme, information tools lead to convergence but provide little room for students to explore different topics or to have differences of opinion.

Meeting the Challenge: Between Information and Communication

Throughout this paper, we have discussed the differences between information and communication interfaces. Theories of learning through social appropriation suggest that learners may move through both communication-oriented and information-oriented activities along their learning trajectory. Can we design software interfaces that support activities that lie *between* information and communication? Here, we describe some innovative interfaces for CSCL from the "middle space" between information and communication that each transcends some of the tradeoffs and suggest how these interfaces avoid the falling prey to one extreme of the design tradeoffs described above.

Participatory centralization with Co-Web

A medium can be both centralized and participatory. The World Wide Web is in many ways extremely open to democratic participation since there is little cost to publish to a global audience and since authoring Web pages is relatively easily learned. However, the Web is an extremely decentralized medium, making it very difficult to locate others' content or aggregate it for the use of an interested group. In addition, while writing web pages may be accomplished without specialized expertise or software, publishing web pages on a server may be restricted through policy or pricing by Internet service providers or employers. A solution that allows both a centralized site for a community and open, inclusive participation is the Co-Web interface (Guzdial, 1998). The CoWeb server (and its predecessors the Swiki and Wikiwiki servers) is a web server in which every page is editable (through a standard web browser) by anyone. Anyone may add pages or annotate or change others' pages. This allows not only individual, monologue-like publishing of pages on the site that are created by individual authors, but more dialogic types

of publishing including annotation, even chat-like discussion in the context of a web page. Commentary and critiques of existing pages can take on more dialogic properties as students quickly post their ideas and respond to those comments. These dialogues across a number of pages can be edited directly back into a more structured and coherent joint monologue. This approach has many of the benefits of centralization, including the aggregation of content created by a community, but also allows wide participation and supports a range of behaviors from individual monologues to discussion, all within the same electronic space.

CSILE: Reflective and Interactive

There is a middle ground between immediate, unreflective interactivity and sustained, but isolated reflection in collaborative media. Computer technology allows the development of linked multiple representations that promote both peer-to-peer interaction as well as reflection. CSILE (Computer-Supported Intentional Learning) is a well-documented interface to support students in self-directed, collaborative knowledge building activities (Scardamalia & Bereiter, 1991; Scardamalia & Bereiter, 1992; Scardamalia & Bereiter, 1994; Scardamalia, Bereiter, McLean, Swallow, & et al., 1989). CSILE is a shared database where students record and respond to the ideas and discoveries of their peers. In many ways, CSILE is a good example of an interface that is both an information and a communication interface; while there are search facilities and keywords to facilitate information-like access to the community's repository, each comment sports social features such as authorship and links to prior contributions. Semantic labels include semi-social categories such as, "My theory for now is..." or, "What I need to know is." Unlike threaded discussion tools, however, these links are not limited to responding to a single existing comment, but can include citation of multiple prior comments or summarization of multiple comments, more in the vein of an information medium. Through this means, CSILE designers hope to encourage consideration of ideas even when they have already been read or responded (Hewitt & Scardamalia, 1998). Similar to the Co-Web, students can engage in dialogic acts, critiquing others' work or interacting with others over time in a coherent context. But students can also engage in monologic activity including summarization and individual, reflective expression; both types of activity have a place in the database.

Multiple forms of coherence: SpeakEasy

The SpeakEasy interface (Hoadley, Hsi, & Berman, 1995a) is a structured multimedia discussion tool designed for learning. While it (and its predecessor, the Multimedia Forum Kiosk) is in many ways similar to threaded discussion tools such as Usenet newsreaders, the tool has multiple structuring features. One such feature is a separate Opinion Area that includes one summary per student of their current position on the topic. This, combined with the fact that all comments are labeled with "picons," or small pictures of the students' faces, provide a structure for browsing socially (by person) in addition to browsing topically (by thread). Another structuring feature is link labels like "And," "Or," "But," "Question," and "Summary" for responses to indicate the discursive relationship to prior comments (see Fig 1). The link labels establish a relational context between contributions. Not only are related contributions located together spatially (as opposed to in the order the messages were sent, which is the norm for most discussion tools), but because of the labels the students can see discursive features at a glance such as whether or not the second message is intended to disagree or add on to the first. These structuring features help the students using SpeakEasy to establish a temporally *and* topically coherent discussion, which is a major problem with many of the existing asynchronous discussion tools (Herring, 1999).

Thus the SpeakEasy structures the dialogue in ways that help the students establish the communicative context, allowing the dialogue itself to focus on the topic of the discussion.

Figure 1: SpeakEasy discussion on heat flow

Secondly, this tool has not been used, as with most electronic discussion tools, exclusively for discussion with distant participants, but rather for communication among co-located peers. One typical usage of the system was for class discussion among middle-school science students in a single classroom where students participated by writing several small contributions (comments on the order of a few sentences) back-and-forth to their peers over several weeks. The tool, in this case, is semi-synchronous in that students could participate simultaneously and receive almost immediate feedback, but the tool never interrupted their composition activities with new, incoming comments. This semi-synchronous usage may have contributed to the lack of topic drift and fragmentation common in other communication tools (Herring, 1999). Because the students were able to respond to the on-going discussion without being interrupted by new messages, they could respond to messages that addressed the topic of interest, rather than just the few most recent messages. This may have contributed to threads not "dying on the vine" but the conversation pursuing a number of parallel and interrelated discussions simultaneously.

Through its structure and innovative usage, the SpeakEasy provides plenty of opportunities for reflection within a coherent discussion (Hsi, Hoadley, & Schwarz, 1992) which plays a role in its effectiveness as a learning environment (Hoadley, 1999; Hoadley & Linn, in press, 1999; Hsi, 1997).

Complementary convergence and divergence: SpeakEasy to SenseMaker activity

Media can be designed to explicitly support both convergent and divergent phases of activity. In one innovative activity, discussion groups of 10-15 middle-school science students used the SpeakEasy discussion tool to generate divergent options and rationales in a design task. After completing the discussion, a special translation tool allowed the students to work (in pairs) with the SenseMaker tool (Bell, 1997; Bell, 1998) to organize and synthesize a single overview of the design issues. (Figure 2) The SenseMaker is designed to allow students to take disparate ideas

and integrate them into a topically coherent visual "argument;" nodes of "evidence" (represented as dots) can be easily dragged into frames which represent "claims" or other ideas. In this activity, students used the SpeakEasy as a communication tool, focusing on dialogic interaction with the topic. Thanks to the translation tool, students could construct more of a joint monologue with their partner in SenseMaker, with each SpeakEasy comment turned into a piece of evidence for their SenseMaker argument. Because the translation tool brought the comments from the discussion into the argument-building interface, the students' previous work was seamlessly brought from the dialogic activity into the monologic one.

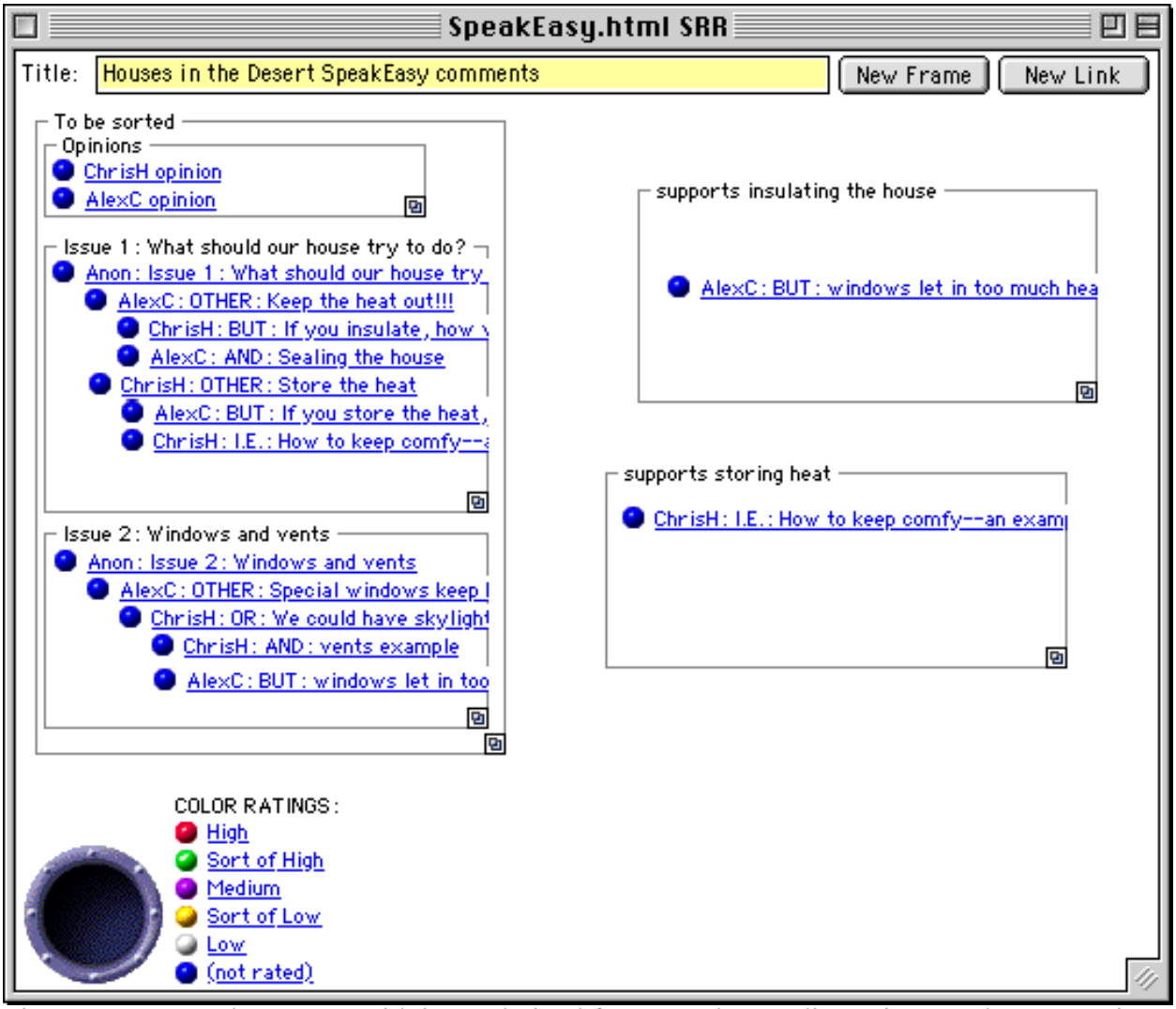

Figure 2: SenseMaker screen with items derived from SpeakEasy discussion. Students organize the items on the left into categories of their own on the right. Clicking on them brings students back to the live discussion.

Where's the middle ground?

There are clearly similarities between information-based interfaces and monologue, and between

communication tools and dialogue. Dialogue and communication tools share a propensity towards context dependence, tightly coupled interaction, and inclusion of a wide variety of communicative cues such as socially relevant representations. Monologue and information tools offer tightly structured ways of presenting information that constrains its interpretation and encourages convergence. Both processes are essential in education. We do not want each student to have a completely different understanding of a domain. Neither do we want students to merely memorize and parrot what a teacher has told them. If we take seriously the concept of a learning trajectory in which students learn first from dialogic activity and move toward the more structured communicative forms of extended monologues, then cycle back to dialogues, the question arises: How may we support students as they move from dialogic activities which we see in communication interfaces towards the more monologic activities of composing and digesting extended texts or utterances, as we observe in information interfaces?

As it stands now, the divide between information interfaces and communication interfaces creates a chasm which learners must cross if they wish to internalize ideas and move towards more expert, independent practice and understanding in a domain. We know from studies of learning technology that gradually fading of scaffolding from a tool, or tools with a gradually sloped learning curve are more effective than sudden drops in scaffolding, or tools with a staircase shaped learning curve. Furthermore, the more different tools seem to the learners, the more likely they are to be perceived as new contexts and the less likely students are to transfer their nascent skills (Lee & Pennington, 1993). This argues for integrating computer supported collaborative learning tools across the continuum—from communication tools to information tools—and for filling in the "middle spaces." The challenge presented to us is to design and build tools that transcend some of the either-or tradeoffs associated with the information-collaboration dimension, to support both dialogue *and* monologue.

Acknowledgements

We gratefully acknowledge those who helped with our prior research on collaboration, including Bernard Gifford, Sherry Hsi, Marcia Linn, and Philip Vahey. We also acknowledge the contributions of those who designed "middle spaces" tools that we use as examples including Philip Bell, Mark Guzdial, and Marlene Scardamalia. Thanks to Ondine Shugart for editorial support. Lastly, we acknowledge financial support from the National Science Foundation, the Spencer Foundation, and the University of California. Opinions expressed here are those of the authors and may not reflect the opinions of our funders or of the authors cited herein.

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Authors' Addresses

Christopher M. Hoadley (chris.hoadley@sri.com)
Center for Technology in Learning, SRI International; 333 Ravenswood Ave.; Menlo Park, CA 94025. (650) 859-2860.

Noel Enyedy (enyedy@socrates.berkeley.edu)
Education in Math, Science, and Technology; 4533 Tolman Hall #1670; University of California; Berkeley, CA 94720-1670.