Socially Relevant Representations in Interfaces for Learning

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Abstract: In this paper we describe a way of looking at how people learn from computer interfaces. In particular, we describe the concept of a *socially relevant representation*, or a representation of social context information (as opposed to domain knowledge information). We describe known or hypothesized mechanisms by which such representations might facilitate learning, and discuss implications for the design of knowledge media.

Introduction: Context as a Clue to Understanding

This paper explores the role that representations of social context information can play in learning. Consider the following experience. Hoadley was a graduate student in an interdisciplinary doctoral program in science education. The first year students came from many different backgrounds in the sciences, and were preparing for an exam to cover readings from a first-year seminar in cognition and education. For many, the papers read were fairly easy to understand—their methods and findings were clear. Still, they were challenged in trying to make a coherent whole of the papers they had read to prepare for this exam. To the students, every paper seemed to have its own goals, emphases, vocabulary, methods, and so on. There was no sense of whether similar terms were distinct in meaning or whether they were synonyms for the same idea. The students lacked a framework with which to integrate the ideas put forth in the papers, and important precondition for deeper understanding (National Research Council Committee on Learning Research and Educational Practice, 1999).

They eventually stumbled on a technique that helped them get a sense of their new field. They grouped the papers, first historically, and then into "camps" of researchers. Questions like "Would this person have known about this person?" "What discipline was this person coming from?" or "Would this person have agreed with this person?" helped to sort out the multiple themes and traditions and understand how they related. Although none of the students had been told this history, they were able to piece it together by looking at dates, citations, and institutional affiliations. Although this took place before the Web existed, it is easy to imagine today that the students might have searched online for each author's career history and CV as well.

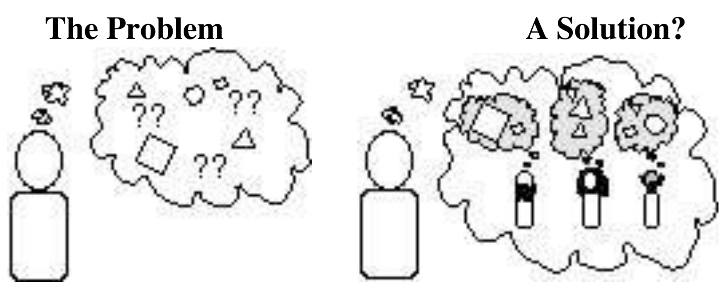

Figure 1. Making sense of a domain via social information.

The point of this story is that even though reconstructing historical information about these papers made extra work for the students, it was this extra information that helped to make sense of the research in the papers. In this paper, we make a case for why social context information deserves a place in interfaces for learning. We describe the concept of *socially relevant representations (SRRs)* for interfaces and other artifacts. These representations may have important effects on learning. We present a rationale for why SRRs deserve a place in educational interface design and explore from a cognitive perspective some ways SRRs may facilitate learning (see Figure 1).

Representations in Educational Media

How do we design representations to foster better learning? Obviously, current educational theory emphasizes a wide variety of learning processes, from apprenticeship and social appropriation to constructivist-linked discovery learning. Media and information design are an important part of many of these approaches. While it is most closely identified with an instructionist point of view (Bruner, 1968), information representations can be viewed as an important part of the learning environment regardless of the educational philosophy used.

A pure instructionist viewpoint might stop at identifying media or representations that accurately and effectively describe the domain that is being taught (with a relatively uncomplicated view of what "accurately and effectively" means). A large body of literature exists that helps define what features effective instructionist representations must have, ranging from properties of information design, textual chunking, or age-appropriate language, to the types of media that might best convey certain messages. A textbook would be the classic example of an educational representation designed for learning in the instructionist approach.

A cognitive constructivist approach to the use of representations to support learning might be concerned with additional questions. What are the decoding processes and memory storage processes that allow the learner to construct an understanding of the representations? How much assimilation vs. accommodation is required to respond to the representations, and will the representations support or hinder conceptual change processes? For instance, a computer program that exposes students of physics to a microworld where physical laws are represented both as images of moving bodies and as graphical force, velocity, and acceleration vectors (perhaps also as mathematical symbols) (White, 1993) might have been designed to foster a particular type of cognition or constructivist activity on the learners' part.

Likewise, representations play an important role in sociocultural models of learning. The acquisition of literacy, for instance, is often studied as a sociocultural phenomenon, as are learners' practices surrounding textual representations as they learn to read (Ravid & Tolchinsky, 2002). This view of representational appropriation extends to other types of representations and learners as well, for instance, representational fluency forms an important part of the practices of chemistry (Kozma & Russell, 1997) or mathematics (Kaput, 2001; Kaput, Noss, & Hoyles, 2001) and learners appropriate the use of these specialized representations as part of their entry into more expert practices. Talmudic-style textual deconstruction activities (Klamma, Jarke, Hollender, & Boerner-Klein, 2002) or performances of literacy might be examples of how educational representations can be designed to foster learning from the sociocultural perspective.

Thus, representations do a lot of work in the learning context, regardless of the particular educational strategy or philosophy. Seeing the representations that form part of the educational environment and trying to optimize those representations is an important part of the design of instruction. In particular, computers give us unprecedented ability to create, manipulate, and share representations of a wide variety of types. Understanding how they do their work, and how we may design them, is vital.

Sensemaking and Representations

One metaphor for understanding the role these representations play in learning is to think about how learners come to do sensemaking with educationally motivated representations. A variety of levels of analysis are possible, from a semiotic symbol-systems level analysis to a media and communications theory analysis to an instructional design analysis. Here, we choose to examine it from a cognitive perspective.

Cognitive scientists, especially those concerned with learning, have examined the role representations can play in learning activities (e.g. diSessa, 1991; Kozma & Russell, 1997; Kozma, Russell, Jones, Marx, & Davis, 1993; Sandoval et al., 2000). While they share with instructionists and usability engineers the goal of allowing a learner to apperceive and decode or comprehend representations of information, they also concern themselves with how learners can generate representations and interact with them in ways that support conceptual development. To illustrate with a few examples from how representations can help students learn Newton's laws, diSessa examined how physics students could use the generation of representations about motion to help them make explicit, refine, and share their underlying conceptualization (diSessa, 1991). White and Fredericksen (White, 1993; White & Frederiksen, 1998) have examined the ways students can interact with simulations that represent aspects of physical motion to question their own assumptions and refine their understanding. And others have examined how multiple, linked representations can be used to scaffold learners to reduce cognitive load and aid in creating links between different conceptualizations of the same scientific phenomena (Kaput, 2001; Kaput et al., 2001; Kozma, Russell, Jones, Marx, & Davis, 1996).

The cognitive perspective on representations can sometimes collide with the information design perspective and the instructional design perspective. With information design, the goal is often to allow the greatest information density (Tufte, 1990; Tufte, 2001), while many in instructional design use a goal of supporting the greatest information comprehension (Bloom, 1956). From this cognitive perspective on sensemaking, however, the focus may be on engaging the learner with less information (to reduce cognitive load or direct attention) or on providing confusing information (to help spark the beginnings of conceptual change processes, e.g. Wiser & Carey, 1983). Piaget's model of assimilation and accommodation (Piaget, 1970) helps explain why this is so; he links the development of new conceptual structures to either assimilation (whereby new experiences are assimilated into the existing conceptual structures with minimal change, as with an instructionist learning environment, such as reading a textbook which is readily understood) or to accommodation (whereby new experiences force reorganization of the underlying conceptual structures, as with for example discovery learning in a microworld). Whether an accommodation or assimilation mechanism is sought, the representations to be used by the learners must have the appropriate affordances to allow them to be used in cognitively appropriate ways. In the case of technology, we have much greater freedom to change features of representations and to use multiple media and interactivity than ever before (say, with paper-based representations) which makes it even more important that we have models of how to design our representations to enhance sensemaking. In the next section, we discuss another way representations may be designed to enhance learning.

Social Cues as a Scaffold for Sensemaking

Above, we have explored some of the ways that external representations can cognitively support sensemaking activities in learning a particular domain. Up to this point, we have considered representations that directly address the content of that domain. For instance, in the case of physics textbooks, we mentioned the ways these books discuss physics concepts. Here, we identify an important additional way to consider what information should be represented in a learning environment. While the representations of domain concepts (such as the physics described in the physics textbook or the models represented in a microworld) has been well studied as an avenue for learning, the ways representations help convey contextual information—metaknowledge, if you will—has been less well studied. In particular, we advocate attending to socially relevant representations (Hoadley, 1999; Hoadley, Hsi, & Berman, 1995), or representations that convey social context information that is not directly related to the domain. Below, we define socially relevant representations and give an example of how they might facilitate learning. Then, we identify examples of SRRs from prior work on social representations in interfaces and their impact. Finally, we discuss (from a cognitive perspective) evidence that these representations can facilitate learning and discuss possible mechanisms.

Defining Socially Relevant Representations

We define socially relevant representations as any representation (presumably in software, but also in other media) which contributes information that is not part of the traditional domain area content, but rather is used for (or derived from) social interaction. For instance, the equation for Newton's third law of mechanics would not be an SRR because it is considered part of the domain of physics. However, the story of how Newton came up with the third law (perhaps even calling it "Newton's third law") is socially relevant information. Socially-relevant is not a sharply distinct category; representations carry information which may be considered "social" to varying degrees, indeed many argue that all representations are interpreted via an inferred social context, and all representations carry both designated and connotated meanings (where social context is connoted, e.g. Langer, 1942). However, certain types of representations are prototypically social, such as representations that identify individual people, their personalities, their goals, their interactions, etc. A representation may simultaneously convey domain content and social context, such as a videotape of Stephen Hawking lecturing on the history of the universe; the representation conveys content in the domain of physics but also carries social context information by providing a representation of Hawking himself (an important figure in the domain), his personality, communication style, the handicaps he faces, and so on.

Socially relevant representations are powerfully congruent with ordinary people's conceptions. A body of work by Nass and others (e.g. Nass, Steuer, & Tauber, 1994) has detailed many ways in which people cue off of social information present in interfaces and respond in ways they use with real social agents. A person might respond politely to a computer that asks the user to evaluate its performance, while giving a more candid response to the same computer when the evaluation software uses a different synthesized voice to speak, as if it were a different "person". This research was used to conclude that computers should therefore be social agents, interacting with the user in much the way that another person would. Microsoft's BOB interface was the product; in the interface, the computer had a guide character that interacted with the user. The user could even configure the personality of the computer, picking a character that was more or less assertive and more or less assistive. However this software met with many poor reviews, largely because it could not live up to the high expectations users had for a sociable interface (Manes, 1995).

Of course, socially relevant representations are subject to the same foibles as other representations. They may be misinterpreted like any other representation, and enough congruence with user conceptions must be maintained. (For instance, a socially relevant representation in physics like a narrative history of the Copernican revolution might not make sense to someone who knew little European history.) Another problem is that social representations themselves will be interpreted differently depending on the social context in which they are embedded. Nonetheless, we believe that socially relevant representations may be generally useful in interfaces for learning, even when the user is not actually interacting with other individuals.

Examples of Socially Relevant Representations for Learning

Below we identify some examples from the literature of how what we term socially relevant representations might help learning, including voice and authorship, emotional context, and discursive structure.

Voice and authorship

Paxton (Paxton, 1999, 2002), has conducted several reviews of K-12 history textbooks that have focused on personal agency and author visibility. One study (Paxton, 2002) compared students' written and think aloud responses to historical texts that were either written with a visible or anonymous author. An anonymous author would write a text without reference to or indication of her own opinions, interpretations, or other forms of personal agency. A visible author, on the other hand, features a strong narrative voice in the text that clues the reader into what the author is writing as fact, observation, or opinion. One result of Paxton's study was that students who received a visible author text showed a higher degree of personal involvement in the essays they wrote while responding to written and oral comprehension questions in a reading-to-write scenario. Paxton wrote about one finding that:

> The participants' think-aloud statements, in aggregate, make clear that those in the visible-author group were more likely to establish conscious relationships with text authors, hold mental conversations with and about those authors, and give more thought to the primary historical information embedded in those texts. Not all of these effects reached a level of statistical significance, but they are nonetheless suggestive (p. 235).

Another observation from the study was that students who read the visible author text, the text that contained references to the author's self, used phrases that indicated personal judgment more often—such as "I think", "in my opinion", "I believe", and so on.

Emotional context

Tu and McIsaac (Tu & McIsaac, 2002) studied online learning environments and explored the relationship between social presence and interaction. They found that three emergent dimensions of social presence—social context, online communication, and interactivity—are important elements of establishing a sense of community among online learners. Their study reviewed, qualitatively and quantitatively, student perspectives of communication experienced as a part of a course delivered through an online course management system (CMS). One observation from their study included CMC users' constant search for methods of self-expression (i.e., creating SRRs) in spite of the (limited) affordances of the medium. Tu and McIsaac found that, "Students used emoticons and paralanguage to compensate for the lack of social context cues in the online communication environment" (p. 143). Interestingly, this compensation was fueled by the participants' drive to communicate more effectively and efficiently. Interviews further revealed that perceived social presence is influenced by the social relationships that the students are able to construct throughout the course of their involvement in the online study.

Discursive structure

Hoadley (1999) studied learning in an online discussion tool and explored the relationship between conceptual change in science and social context representations. One study examined the role of discursive structure (threading) in a discussion activity about design choices embedded in a larger design project. In the discursive condition, students contributed to a threaded discussion with comments labeled with headers indicating their discursive relationship to prior comments ("and," "or," "but," "?" and so on); in the control condition a topical structure was used instead, with topical subject headers, approximately the same number of levels of hierarchy and an otherwise identical interface. The learners in both conditions participated equivalently with no significant differences in number of contributions made, quality of comments, etc. However, students in the discursive condition were significantly more likely to change their scientific interpretations of the problem on a posttest, and more likely to change their own designs in the larger course project than those in the topically structured condition.

Social agents

The research of Moreno, Mayer, and colleagues has pointed towards the value of social agency in computer-based teaching environments. One set of studies (Moreno, Mayer, Spires, & Lester, 2001) demonstrated that both college and junior high school-level students who interacted with animated pedagogical agents were better able to transfer their knowledge for use in novel situations, and the students were more interested in the material and more eager to interact with the instructional program again. Furthermore, the students who used the animated pedagogical agent produced significantly more correct solutions on difficult transfer problems than those who received the instructional content from text.

These examples may not be a comprehensive catalog of types of socially relevant representations, but they show some of the promise of SRRs. From the examples we can see socially relevant representations of various sorts that are distinct from the domain content have been demonstrated to enhance learning. This suggests that we should investigate the mechanisms by which such representations facilitate learning to better understand how we may design learning interfaces with them.

Theories on Mechanisms for Socially Relevant Representations

The most obvious mechanism for socially relevant representations to aid in learning is if these cues aid in collaboration activities, which then facilitate learning. However, there are several possible mechanisms by which they may directly facilitate learning. These mechanisms may also be part of the causal pathway by which collaborative learning activities serve to support individual learning. Here, we condense the eight mechanisms hypothesized by Hoadley (1999) and link them to one related mechanism hypothesized by Mayer and Moreno. The shortened list is summarized in Table 1 below.

The first two mechanisms proposed by Hoadley are related to increased motivation. One possibility is that the use of social representations increases intrinsic motivation by making the learning context more similar to (presumably intrinsically motivated) social interactions. The second possibility is that socially relevant representations increase motivation by increasing the learner's sense of social presence (International Society for Presence Research, 2003a, 2003b) and perceived audience, thereby "raising the stakes" for students to contribute reasonable effort to avoid embarrassment or increase social stature.

One additional model of how socially relevant representations may facilitate learning relates to the misapplication of social schemas to inanimate objects (Nass & Moon, 2000; Nass et al., 1994). Social agency theory (Mayer, Sobko, & Mautone, 2003) contends that the activation of social conversation schema in learners can be activated by social cues embedded into the instructional media (consistent with Nass), and that the activation of such schema elicits increased motivation. Mayer et al. propose that "once learners interpret their interaction with a computer as social, the rules of human-to-human communication come into play, so they try harder to make sense of what the computer is saying by engaging in deep cognitive processing" (p.419). While this is not identical to the means proposed by Hoadley, all three share a causal pathway through motivation and engagement. We summarize these three as *SRR as motivator*.

Another mechanism by which SRRs may aid in learning is by serving as an index or mnemonic to ideas in the content domain. Just as the ancient Greek rhetoricians used the method of loci (memorizing a speech by associating points with geographic locations along a familiar walk), connecting ideas to social background information may provide additional associations to help learners remember ideas. We term this *SRR as mnemonic*.

A third general mechanism is the use of SRRs to aid in interpretation and coherence judgments. Connecting and linking ideas is an important part of conceptual change (diSessa, 1988; Linn, 1995) and development of a sense of which ideas cohere with each other is an important part of both evaluating and understanding ideas (Ranney & Thagard, 1988; Thagard, 1992). Since individuals try to present themselves as coherent in social situations, social cues may help learners judge which ideas cohere; for instance, one would expect ideas from the same person or people trained similarly to be more coherent than those that come from other "camps." This is a specialized version of the more general problem of communicative interpretation and other manifestations are also possible. For instance, social cues might serve as aids to directing attention as people make sense of various representations. As McLuhan said, "the medium is the message," and contextual cues are an important part of how people learn to interpret ideas. We term this *SRRs for contextualized interpretation*.

A final possible mechanism is that social cues can be used to aid learners in constructing runable mental models of other people as a means to understanding a domain. Development psychology identifies perspective taking as an important and sophisticated reasoning ability that may be related to the ability to maintain mental models of others' reasoning (Flavell, 1985). This perspective-taking ability has been linked to conceptual change in science as mediated by scientific reasoning and the development of scientific epistemology (Dunbar, Klahr, & Fay, 1989; Fay, Klahr, & Dunbar, 1990; Kuhn, Amsel, & O'Loughlin, 1988). Development of perspectives and mental models of others presumably requires contextual information about the other person and SRRs may provide this context information. Once a learner has enough information to construct a mental model of another's' viewpoint, this could conceivably be used not only to help make coherence judgments for linking and distinguishing ideas (Linn & Songer, 1993) but could also be used to help bracket entire belief systems in order to support conceptual reorganization in conceptual change (Carey, 1991; Kuhn, 1989). We term this *SRRs for prediction*.

Table 2: Sample hypothesized benefits of social representations for learning.

SRR as motivator Social representations may generally motivate students to participate, either by making participation more fun or by raising the stakes for student participation through perceived social consequences in the learning activity.
SRR as mnemonic SRRs may serve as a mnemonic to ideas that students encounter. Learners may be able to better coordinate multiple clusters of ideas (such as complex interpretive frameworks like scientific theories) when these ideas are tied to individuals or fit within a social schema.
SRR for contextualized interpretation Learners may be accustomed to assembling coherent, competing views from observing social acts. For instance, a student may try to interpret an online discussion in terms of which "sides" people are on, helping form a coherent picture of each competing viewpoint. Or SRRs may provide cues to which ideas are consistent, in the form of which are jointly held by an individual person and which conflict.
SRR for prediction If a learner can develop a mental model of another social agent and their goals and beliefs, the learner may be able to predict other beliefs or goals held by that agent. "What if" scenarios may help learners explore the implications of ideas or theories without overt social interaction, by playing out scenes in their mind.

It is important to note that these proposed mechanisms are in addition to other second order benefits that might derive from how representations support group processes that then might aid learning. So, for instance, while social representations might directly increase motivation, they might also facilitate task coordination in a collaborative setting, and that more efficacious task coordination might itself be motivating.

Conclusions

Thus, socially relevant representations can help scaffold learners by providing social context cues in learning media. Concern for the learners' perception of the social relevance of educational representations should be the responsibility of the learning technology designer. Contemporary learners of all ages are wading through a morass of irrelevance in the education they receive, rather than participate in. We believe this is partly due to a lack of social information that would offer learners a greater opportunity to hang their content knowledge upon mental structures related to social context. The theory of socially relevant representations suggests multiple mechanisms for enhancing the meaningfulness of educational media. We believe it is a context-driven yet domain general theory for design, applicable to learners of all ages, cultures, and backgrounds. Further work is needed to help explore the mechanisms by which socially relevant representations facilitate learning, to explore individual differences in the use of SRRs, and to develop design guidelines that spell out when SRRs may help vs. hinder learning.

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