A Social-Constructivist Adaptation of Case-Based Reasoning: Integrating Goal-Based Scenarios with Computer-Supported Collaborative Learning

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In this article, we propose a social constructivist adaptation of Case-Based Reasoning (CBR) (Schank, Berman, & Macpherson, 1999) by incorporating computer-supported collaborative learning (CSCL) tools such as *Knowledge Forum* into the thinking and reasoning process. Goal-Based Scenarios (GBS) are Roger Schank's translation of Case-Based Reasoning into simulated learning environments. In essence, by incorporating CSCL tools into GBSs, we illustrate how the social constructivist process is facilitated through facilitation cues and a simple polling mechanism within the CBR process.

Case-Based Reasoning

We have found *Case-Based Reasoning* (Schank, Berman, & Macpherson, 1999) a suitable framework for active learning because it depicts a process of thinking and reasoning which deals with problems or scenarios. The Case-Based Reasoning (CBR) process is very similar to how people engage in the problem-solving process of everyday life. CBR has much in common with (radical) constructivism—both claim that an individual builds his/her knowledge for himself or herself from experiences. Both see the learner as an active individual with an intentional role in deciding what to do with the activities of life and of learning. CBR has also similarities with construc*tion*ism—where interpretations are closely linked to concrete experiences (Kolodner & Guzdial, 2000).

Case-Based Reasoning, however, goes beyond constructivism, because it defines a model of cognition, including processes and knowledge structures, that can be translated into the design of simulated learning environments (Schank, 2002). In essence, CBR begins by defining a motivating goal related to real-life problem solving. From such a goal, learners or people in general usually draw an expectation of what the goal would be like so that plans will be formulated as to how to execute the goal through which experimentations are made. If what is experimented upon fails in some way, an expectation failure occurs and an attempt is usually made to explain what went wrong (Schank, Berman, & Macpherson, 1999). See Figure 1 for our interpretation of CBR.

If the *goal* were a task that has never been attempted before, one would normally draw upon some analogies or themes and reason across contexts. When something is experimented upon and does not take place according to one's expectations, one would need an explanation. Such an *explanation* is indexed to the failure or experience—thus indexing (for memory) to rich and meaningful contexts (see Figure 1).

Goal-Based Scenarios

Goal-Based Scenarios are Schank and his colleagues' translation of CBR into simulated learning environments. Goal-Based Scenarios (GBS) start by defining a learning *goal* that would be motivating for the students to learn. An example given is to "Advise the President" about the civil war in "Krasnovia" (see Schank, Berman, & Macpherson, 1999, pp. 172–173). The *mission* is thus to engage students in tasks that would ultimately cause them to learn while attempting to achieve the goal. The *cover story* is the background story line that creates the need for the mission to be accomplished. The cover story must allow students enough opportunities to practice the skills needed to learn what should be taught. It must be motivating and interesting to the student. The *role* defines 'who' the student(s) will play within the story. It should be a role which allows the student to practice as many *operations* needed to learn the concepts required (according to the instructional objectives to be achieved), for example, asking experts for opinions, compiling relevant information, and making claims about strategies. *Resources* provide the information the students need to achieve the goal of the mission. These resources can be in the form of stories and, based on these stories, students can make inferences to their current case. These stories can serve as memories for

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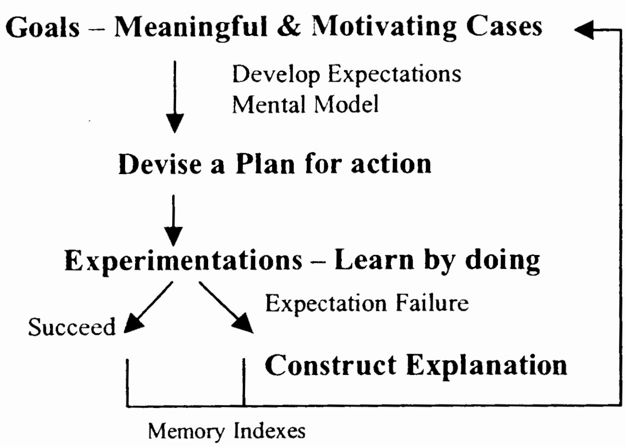

Figure 1. Our interpretation of CBR.

cases to be activated and transferred to current situations. *Feedback* allows learners to properly index information which is integral to the learning process. From the Goal-Based Scenarios, we adopt the following tenets:

- *Goal Setting:* There is a need to provide a cover story to set a meaningful setting for learning.
- *Motivation:* The cover study must be interesting and relevant to the learner.
- *Roles of the learner:* There is a need to engineer a specific role for the learner(s) in engaging in tasks and operations where he or she can practice the skills and knowledge required for achieving the 'instructional objectives.'
- *Learning activity:* There should be plenty of opportunity to operate within such a learning environment.
- *Resources:* There is a need to provide information resources in the form of related stories.
- *Feedback:* Learners should receive appropriate feedback either from the human teacher or the simulated learning environment.

A Social-Constructivist Version of CBR

We are proposing an adaptation to the CBR process in the following way: From the learners' perspective, they engage in the thinking and reasoning process through the social constructivist Case-Based Reasoning framework as described in Figure 2. The goals for the learners are cases/problems that are authentic to them because (we are proposing that) they were part of the problem formulation process. They engage in CBR collaboratively and through the mediation of cultural artifacts. With a goal at hand, the learners co-devise a plan of action in order to solve their case/problem. The community of learners as a whole examines results of the action against the expectations of the negotiated model. Within this problem manipulation space, the community makes use of related stories/cases in its reasoning process and uses various kinds of tools to manipulate data and collaborate with one another, including teachers/experts according to their specific roles and functions (see Figure 2).

From the co-experimentations, the community of learners either succeeds or fails in their attempts. When expectation failures occur, reflection and explanations can be made in consultation with others, including the use of artifacts. These reflections are in essence what constitute learning (Schank, Berman, & Macpherson, 1999). We add the process that when experiments succeed, "what-if" questions should be posed by the community to strengthen further understanding in order to test for generalizability or the transfer of meanings (see Figure 2—details in *italics* are our adaptations to the Case-based Reasoning process). Within the social constructivist Case-Based Reasoning process, the following adaptations have been made:

- Goals co-formulation with all learners involved.
- Negotiation of mental models or co-construction (co-setting) of expectations from learners.
- Co-devising of plans for action or experimentations.
- Co-experimentations resulting in the co-observations of results against the co-setting of expectations formed earlier.
- Co-explanations of expectation failures by the learners as a community.
- "What if" questions posed by the community.

With the above social constructivist adaptation of the CBR process, we now describe how Computer-Supported Collaborative Learning (CSCL) environments—that is, the tools and functions within CSCL—can support the thinking and reasoning processes.

Computer-Supported Collaborative Learning (CSCL)

Computer supported collaborative learning (CSCL) has grown out of an integration of computer supported collaborative work (Ellis, Gibbs, & Rein, 1991) and collaborative learning. CSCL focuses on the *learning* dimensions of what is being communicated, and the purpose is to scaffold or support students in learning together effectively. Theories undergirding CSCL include distributed cognition (Hutchins, 1991), Vygotsky's social-cultural theories of the mind (Vygotsky, 1982), and cognitive flexibility (Spiro & Jehng, 1991). CSCL aims at providing both an authentic environment and multiple perspectives that can tie in students' prior knowledge, holding to the underlying

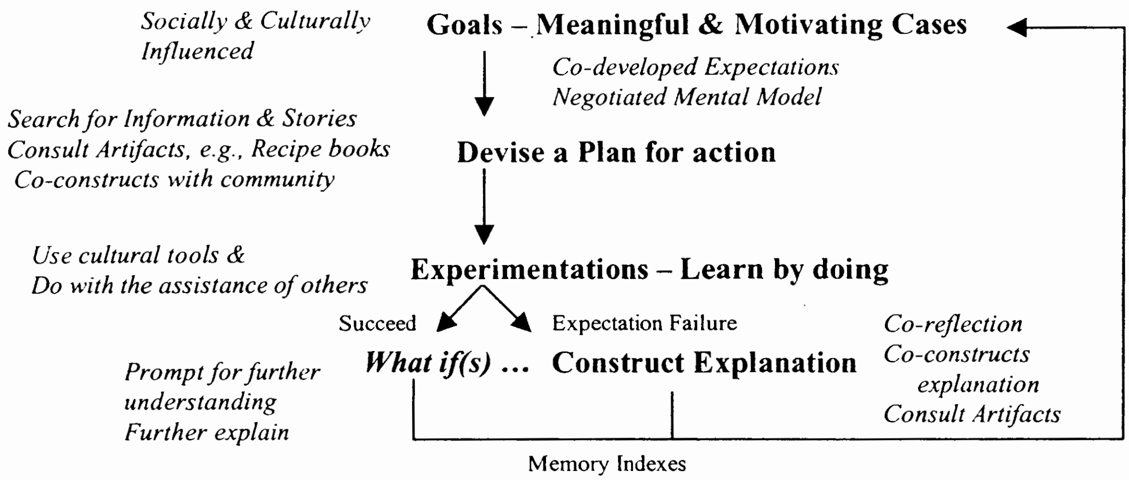

Figure 2. Social constructivist adaptation of CBR.

assumption that individuals are active agents and that they are purposefully seeking and constructing knowledge within a meaningful context. Though each CSCL tool may have different functions, one general characteristic is to promote reflection and inquiry that assist in-depth learning. By supporting the Case-Based Reasoning process (albeit the social constructivist adaptation), we are arguing that in-depth learning occurs. Another example of in-depth learning within CSCL is in Computer-Supported Intentional Learning Environments (CSILE) (Scardamalia & Bereiter, 1991), or *Knowledge Forum* (which will be explained below).

In general CSCL applications support:

- Communication, discourse, & distributed coordination (e.g., *Teamwave*, http://www.teamwave.com).
- Tools for co-thinking, co-reflection,and co-visualizations (e.g., *idons-for-thinking*, http://www.idongroup.com/idonsoft/soft.htm; and *CoVis*—Learning with Collaborative Visualization, http://www.covis.nwu.edu/).
- Scaffolding in thinking and communication (e.g., *Knowledge Forum*, http://www.knowledgeforum.com).

Integrating GBS with CSCL

Although in the descriptions of GBSs, social-others can be involved in the learning activities, there is no explicit mention of computer-supported collaborative learning tools embedded into the simulated learning environment. We are proposing that CSCL tools can be part of the thinking and reasoning process within GBSs. Implied in the GBS environment, learners adopt the Case-Based Reasoning process, since GBSs are grounded on simulated *cases* upon which learning is facilitated. Processes such as *feedback* and *resources* are also provided in terms of cases and related stories, aimed at aiding learners in the process of setting *expectations* and how to go about becoming engaged in the *experimentation* phase. When *expectation failures* occur, learners are also meant to consult related stories of incidents and situations captured in the database. In order for goals to be intrinsically motivating to learners, they would have an opportunity to have inputs into the cover story of the GBS, for example, the war in Krasnovia. Although teachers can set this cover story as an instructional goal, learners should be able to authenticate whether the cover story is indeed motivating as a learning goal. In other words, we are suggesting that learners be provided the opportunities to co-construct the cover story and thus the mission for their collaborative learning goals.

Although in general GBSs are not CSCL environments, we are proposing that CSCL tools can support the GBS design processes in the following ways:

- CSCL can provide tools to assist learners in problem co-formulation. Learners can be engaged in a discussion with tools such as *Conversant Media* (developed by Kent Ridge Digital Labs), which allows a threaded discussion around a video-based cover story case.
- CSCL can provide discourse tools for feedback. Learners can discuss and provide feedback to each other through the CBR process—co-setting

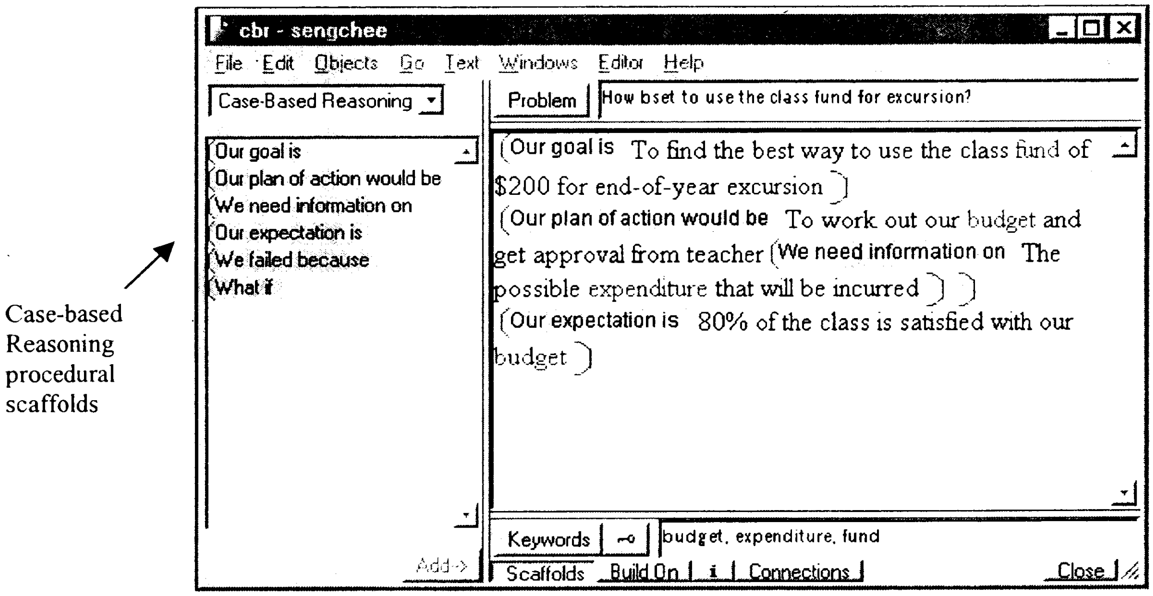

Figure 3. Procedural scaffolding cues based on CBR.

of expectations, co-planning, co-experimentations, etc. CSCL such as *Knowledge Forum* (http://www.knowledgeforum.com) and *Teamwave* (http://www. Teamwave.com) can support such a process,

- In addition to the repository of cases and stories in GBS, CSCL tools can provide learners with access to experts who can be valuable resources. The CSCL can also customize relevant information resources for the learners to consult.
- CSCL can be used to support the discussion processes while learners experiment with the ideas and plans set forth. Communicative tools coupled with concept-map like applications such as *idons-for-thinking* (http://www.idongroup.com/idonsoft/soft.htm) can be useful. Jonassen's (2000) mind-tools would also be appropriate here.

Two Additional Enhancements to GBS with CSCL

In our social constructivist adaptation of the Case-Based Reasoning process, we are recommending two enhancements: the incorporation of facilitation cues to the CBR thinking process, and the inclusion of a polling system. Firstly, in our earlier conceptualizations (see Figure 2), we had mentioned that through such a platform (see Figure 3), learners can engage in goals co-formulation with all learners involved (i.e., "Our goals are"), co-setting of expectations (i.e., "Our expectation are"), and co-explanations of expectation failures (i.e., "We failed because"). The above cues such as "Our goals are" can be incorporated into CSCL environments such as *Knowledge Forum*, which can serve as thinking cues for learners (see Figure 3). Procedural scaffolding cues assist the learners' thinking by facilitating the starting of a sentence construction with that particular cue, such as: "Our goal is to find the best way...".

Briefly, *Knowledge Forum* (a second generation CSILE; see http://www.knowledgeforum.com/) is a networked, collaborative learning environment designed to support a Knowledge-Building Community (see Scardamalia & Bereiter, 1991). The CSCL tool permits learners to share information and answer each other's questions in the online environment. The strength of this approach is that it objectifies the knowledge of the community and makes advancement of that knowledge as a social collaborative activity. All questions, theories, ideas, information, and discoveries are preserved on the database for the analysis of the entire online community.

Within the social constructivist adaptation of CBR, we have also incorporated the "What ifs" in order to move learners away from specific cases and stories (which in essence are real-world concrete experiences) to abstracted understanding where generalizations and transfer of meanings can occur. Bereiter (1997) refers to the dialectical process between world 1 (real-world) to world 3 (immaterial objects based on abstraction) as a hypothetico-deductive method, in which he feels that all schools should engage their learners. For transfer of

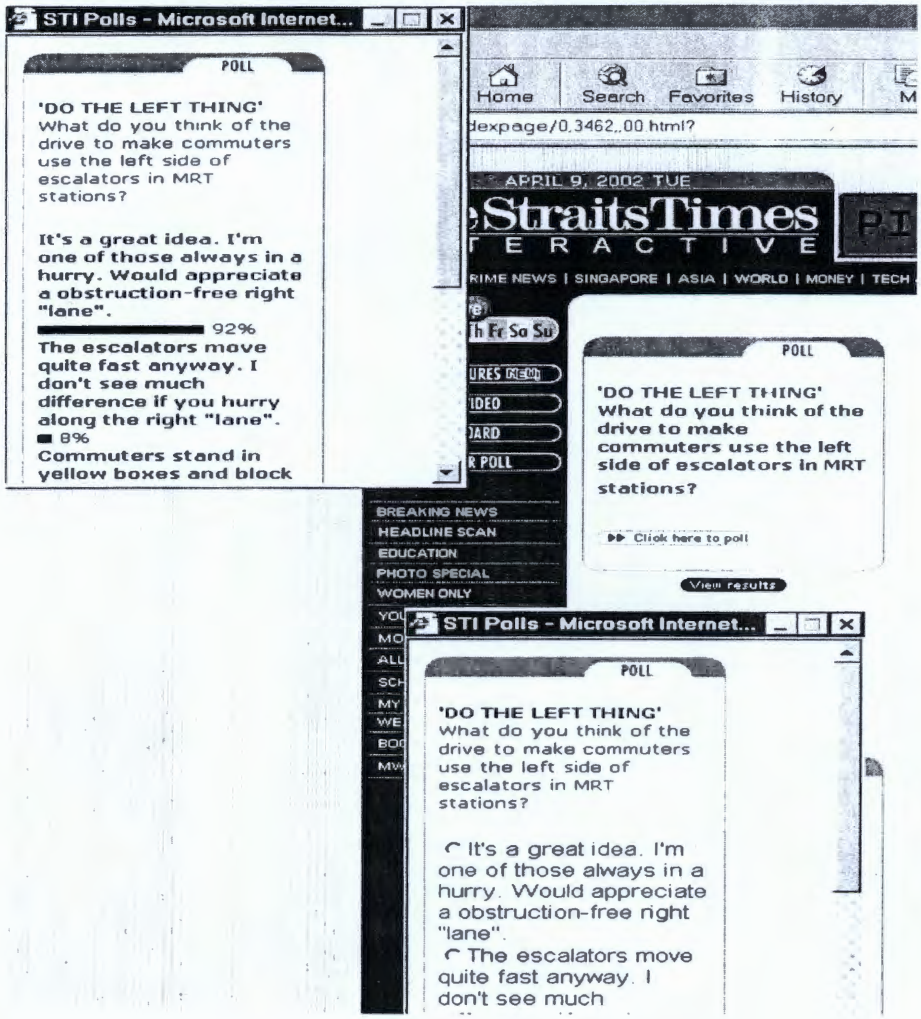

Figure 4. An example of a polling mechanism.

meanings to occur, the constraints and affordances of two (or more) situations must appear different on the surface but there is some form of *abstract* relationship. It is a relationship based on formal, structural, or logical correspondences (Bereiter, 1997). Bereiter (1997) argues that schools should engage students in producing knowledge objects—theories (or theory-like conjectures), interpretations, historical accounts, problem statements, defenses based on evidence, and so on.

A second enhancement is the incorporation of a polling system. As each phase of the CBR process (see Figure 2) is collaborative in nature, all decisions should be made based on consensus. However, most existing CSCL tools do not have a good support for this decision-making process. Often, the community will have to wait for everyone to come online and specifically spell out his/her opinion before a decision can be make. Even so, on many occasions, individuals may not state their opinions clearly enough, so much so that additional clarifications are necessary. This is very time-consuming and often frustrating to the enthusiasts. A possible situation could be that there are two (or more) competing cases in which participants would like to be engaged. Due to time and resource constraints, there is a need to choose one or the other. The facilitator may have to propose that participants make a choice. After the posting of the choice to be made, the community would have to patiently wait for most participants to contribute and wait for the facilitator to collate the ballots. This is very inefficient and it could be inhibiting to the main learning activity.

We suggest additional functions which support rating or polling of views held by the learners in the community might be necessary. Polling of views in relation to the co-formulation of goals, co-devising of a plan for action, co-deciding on whether solutions meet with shared expectations, agreement on whether explanations of expectation failures, and so on require consensus in opinions and views. Such processes can be facilitated with a simple polling or rating mechanism. One such scenario could be that any participant could propose a proposal and it will have to be seconded by a fixed number of members in the community. Once that is done, the CSCL system will collate all ballots and even automatically remind those who have not voted. Within a fixed period of time (hopefully much shorter), a decision can be made and the learning activity continues. These polling and ratings mechanisms are already common in many sites such as interactive newspapers where polling of view is done (see Figure 4).

In summary, according to our conceptualizations of a social constructivist version of CBR and thus GBS supported by CSCL, we are suggesting the following adaptations:

- In order to facilitate problem co-formulation, learners use a problem co-formulation tool (which could be a video-based discussion platform).
- In order for learners to discuss and collaborate with each other and with resources outside their group, CSCL communicative tools can be provided.
- In order to facilitate the CBR thinking process and generalization from specific cases, we also suggest that learners, as facilitated by procedural facilitation cues (as in Knowledge Forum customized according to the CBR processes).
- In order to support experimentations, cognitive tools for organizing knowledge and concepts in the form of schemata should be provided for learners.
- In order to facilitate the provision of reaching consensus (e.g., the setting of expectations) throughout the collaborative CBR process, a simple rating or polling mechanism be provided.

Conclusion

There are aspects of the social constructivist adaptation of the Case-Based Reasoning process not supported by CSCL as described by us. For example, CSCL tools could function to support the various roles and functions played in the scenarios which the community of learners are to engage in. Different roles involve a different degree of participation and tools involvement. Learners also ought to rotate their roles such that all members have a relatively equal opportunity to learn the required skills and knowledge which each function affords. The function of simulated feedback in terms of stories and cases can also be integrated into the design we have proposed in this article.

In essence, we have emphasized the collaborative and social dimensions of learners' involvement in the CBR process, whereas Schank and his colleagues seem to focus more on the computer-simulations within GBS. Both dimensions, in our opinion, can be capitalized upon and enhanced for learning. □

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