Kao, G. Y.-M., Lin, S. S. J., & Sun, C.-T. (2008). Beyond Sharing: Engaging Students in Cooperative and Competitive Active Learning. *Educational Technology & Society*, *11*(3), 82–96.

Beyond Sharing: Engaging Students in Cooperative and Competitive Active Learning

Gloria Yi-Ming Kao
Department of Computer Science, National Chiao Tung University, Hsinchu, Taiwan 300, R.O.C. // gis92801@cis.nctu.edu.tw

Sunny S. J. Lin
Institute of Education, National Chiao Tung University, Hsinchu, Taiwan 300, R.O.C. // sunnylin@faculty.nctu.edu.tw

Chuen-Tsai Sun
Department of Computer Science, National Chiao Tung University, Hsinchu, Taiwan 300, R.O.C. // ctsun@cis.nctu.edu.tw

ABSTRACT

The authors describe their design for an Internet-based learning environment called BeyondShare in which students are encouraged to gain a deep understanding of the learning material, reflect on the quality of individual constructions through sharing and peer evaluation, and synthesize cross-unit knowledge by integrating self- and peer-produced constructions. A sharing typology may consist of basic sharing, sharing with notification, sharing with feedback, or sharing with interaction. BeyondShare distinguishes itself by combining sharing activities with task structuring and cooperation/competition to achieve active learning. A formal evaluation of BeyondShare was performed with a class of 34 college students who created concept maps for a computer programming language and who were encouraged to become active learners by exchanging roles throughout the experiment. Evaluation results indicate that the students viewed BeyondShare as an easy-to-use environment that motivated them toward comprehensive knowledge integration by sharing construction products with their peers. Potential activities and suggested modifications are discussed.

Keywords

Active learning, Cooperation, Competition, Distributed sharing construction, CSCL environment

Introduction

The concept of sharing has taken on new importance in a world that has the Internet — a tool that allows for resource access from any place at any time. Examples of Internet-based sharing include personal websites, blogs, discussion forums, and instant messaging; a growing number of applications support sharing using different media (e.g., del.icio.us, Flickr, and YouTube). These tools disseminate individual or group beliefs in a manner that binds geographically dispersed individuals with common interests. When applied to group-based pedagogy, the anyplace-anytime characteristic enables a shift from real-time learning to asynchronous distributed learning (Kreijns, Kirschner, & Jochems, 2002). The same characteristic enables researchers to create sharing activities that entail concurrent, multi-user interactions (Greenberg & Marwood, 1994; Yang, Chen, & Shao, 2004). One example is the use of information technology tools to share musical ideas via exchanges of audio files instead of through verbal discussions of concepts (McCarthy, Bligh, Jennings, & Tangney, 2005).

However, many pedagogical or research projects address the how or what of sharing to benefit collaborative learning without questioning the why or examining the effects of sharing on learning contexts. To reap the benefits of collaboration entailing mutual engagement as opposed to simple cooperation entailing labor divisions (Roschelle & Teasley, 1995), teachers and researchers frequently design tasks that involve information sharing followed by discussion (see, for example, Häkkinen, Järvelä, & Mäkitalo, 2003). The interactive structure of computer-supported collaborative learning (CSCL) environments creates additional constraints or freedom for learners. One of several impediments to a desired social interaction is the tendency to assume that it will automatically occur because the environment makes it possible (Baker, Hansen, Joiner, & Traum, 1999; Kreijns et al., 2002). Research suggests that few students are willing to participate in CSCL discussion forums without some additional motivation, and that factors such as social loafing (e.g., the "free-rider" and "sucker" effects) can lead to responsibility diffusion (Barron, Kerr, & Miller, 1992). Consequently, spaces set aside for collaboration or cooperation are often misused for chatting or storage at the expense of the desired goal of collaborative learning through sharing.

Such discrepancies may be due to a lack of sufficient structure — for instance, the failure of teachers to completely organize learning tasks. We addressed this issue by viewing sharing as an intermediate step in a process consisting of active engagement in meaningful learning and knowledge integration. Specifically, learning roles are made more active and meaningful as students a) construct personal concept maps for an assigned learning unit, b) share personal concept maps across units while critically evaluating their peers' contributions from other units, and c) actively integrate concept maps across all units using a meta-plan to create a "patchwork" of knowledge. Process details will be described in a later section.

In other words, our BeyondShare approach emphasizes the integration of cross-unit knowledge in pursuit of personal goals to generate productive exchanges among students. Instead of expecting students to automatically share resources and negotiate with each other in a CSCL environment, we injected a sense of competition to encourage active learning. As part of this sharing process, we introduced a cooperative competitive learning (CCL) strategy (Lin, Sun, & Kao, 2002) that accommodates both cooperation and competition in a manner that yields greater intrinsic motivation (Johnson, Maruyama, Johnson, Nelson, & Skon, 1981; Tauer & Harackiewicz, 2004).

Our formal evaluation of BeyondShare was designed to answer the following research questions:
1. How many students are able to finish "beyond-sharing activities" (to be described in a later section) using BeyondShare?
2. Did students perceive BeyondShare as easy to use?
3. Did the three activities designed for BeyondShare evaluation achieve the goal of promoting active learning?
4. What percentage of students became actively engaged in both personal and sharing construction?
5. Did a larger percentage of students engage in active learning during personal construction or sharing construction activities?

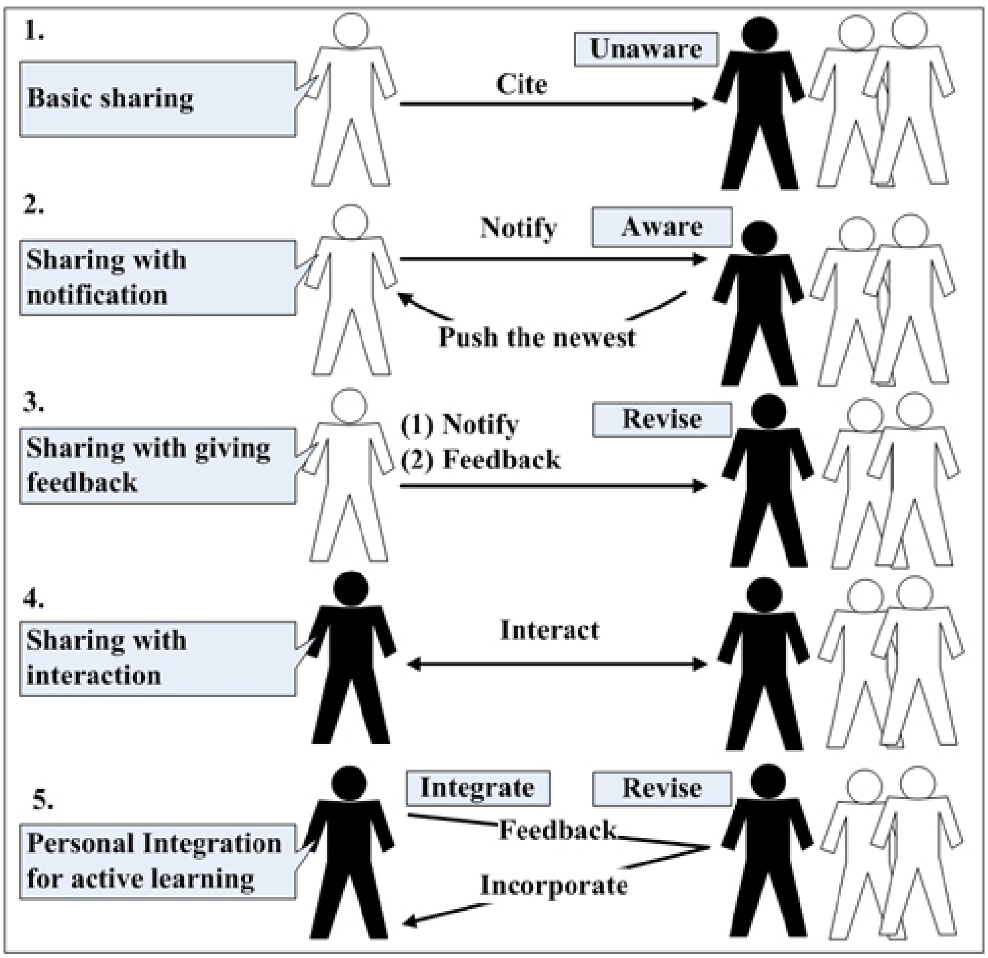
Background

Sharing

A considerable amount of research in this area has focused on building a shared sense of understanding or meaning, that is, finding common ground within groups in collaborative learning settings (e.g., Baker, Hansen, Joiner, & Traum, 1999; Mulder, Swaaj, & Kessels, 2004). Four categories can be created according to this perspective (items 1–4, Fig. 1; black silhouettes represent students who play active roles):
1. Basic sharing. Citing or using an idea from a peer is the most basic sharing format. However, most learning situations lack proper motivation for sharing; therefore, some self-regulated individuals model or cite works while others do not, even when requested or instructed. Furthermore, those who benefit from sharing usually have no channel for notifying idea originators, who therefore remain unaware of how others use their ideas.
2. Sharing with notification. In this variation of basic sharing, cited authors are notified that their ideas are being used. Various technologies, such as Really Simple Syndication (RSS), allow authors to push their latest ideas to subscribers, thus facilitating the timely spread of knowledge.
3. Sharing with feedback. By providing feedback, users help the original authors revise and improve their work. The Computer-Supported Intentional Learning Environment (CSILE) constructed by Scardamalia and Bereiter (1991) is one example of a method designed to promote user feedback.
4. Sharing with interactions. Authors can interact via discussion threads, for example, Greenberg and Marwood's (1994) GROUPKIT (see also Yang et al., 2004). However, participation requires individual motivation.

Researchers such as Häkkinen et al. (2003) and Mulder and Swaak (2002) have used qualitative, quantitative, or a combination of the two approaches to assess collaboration during the sharing process. Completed acts of sharing are followed by quality discussions. Special attention must be paid to the effects of group dynamics on shaping shared meaning (Stahl, 2005), while acknowledging that shared contributions cannot be accepted as indicators of shared understanding among all team members (Beers, Boshuizen, Kirschner, & Gijselaers, 2005). In other words, it is important to separate the term *shared knowledge* (Edmonds & Pusch, 2002) from *shared understanding* or *shared* *meaning*. While researchers expect to bring shared understanding into full play in a collaborative learning context, they must note whether the learning activities are structured in a manner that facilitates mutual understanding rather than simple exchanges of information.

Today's Web 2.0 (O'Reilly, 2005) technologies facilitate different applications (e.g., blogs, Wikipedia, del.icio.us, Flickr, YouTube) that support the sharing of various kinds of multimedia content. These applications are popular because users enjoy expressing their own viewpoints by distributing their articles, bookmark collections, photos, or video clips, and readers/viewers enjoy or use the information gathered from the shared works. These applications all have the same key element: providing users with spaces to share their work and/or to find others with similar interests. In other words, to some degree they all fit into one or more sharing typology categories. For example, most bloggers are interested in sharing hyperlinks with others interested in the same domain knowledge, yet bloggers in the same domain may compete to attract more visitors to their blogs and therefore work to maintain a favorable page ranking on a major search engine. This phenomenon suggests that competition is a motivating factor for bloggers to update and improve their articles.



*Note: Black silhouettes represent students who play active roles.

Figure 1. Sharing for shared understanding (item 1–4) and active learning (item 5)

Beyond sharing: Personal integration for active learning

As Suthers (2005) suggests, the online replication of face-to-face learning is not acceptable as a CSCL goal; the same is true for using CSCL to duplicate social interactions over the Internet. Instead, educators should aim at using the unique features of the Internet as a large resource pool, especially its distribution characteristic (Scardamalia &

Bereiter, 1991). When designing BeyondShare, we purposefully implemented the sharing construction principle (Resnick, 1996) to encourage students to share and reuse ideas from each other's constructions. Examples of approaches that require students to reuse or model parts of their peers' projects to enhance their own personal integration include LEGO MindStorms (Resnick, 2002) and Knowledge Soup (Canas et al., 2001).

In addition to shared constructions, we injected a sense of competition into BeyondShare to promote active engagement. As depicted in item 5 of Figure 1, students become active learners for the purpose of integrating personal knowledge. They are encouraged to evaluate their peers' efforts regarding other learning units, select "personal best-fits," and incorporate works they define as useful into their final personal products. Understanding of the learning material is strengthened through a process of incorporating ideas from their peers' personal constructions as well as through reflecting on feedback concerning their own constructions.

Students compete to have their constructions selected by others as the most useful. As with bloggers, competition is used to motivate students to create, update, and upgrade quality products to share with others, as well as to evaluate their peers' work in a serious manner. Through this competition, they gain a more comprehensive understating of the learning material. Each student plays several roles and has specific responsibilities throughout an activity. The interchangeability of those roles encourages students to become active learners rather than passive information receivers (Table 1). Details will be described in the Procedure subsection of the BeyondShare Evaluation section.

Table 1. Beyond-sharing activity structure

Expected learning outcome	**Task unit**	**Student role interchange**	**Cooperation goal**	**Learning format**	**BeyondShare support***
1. Construct a personal concept map	Within a given unit	Active sharer vs. passive recipient	Personal accountability	Meaningful learning: reading, understanding, organization	Personal construction interface
2. Compete to be chosen by other students	Within unit, cross-unit	Within-unit competitor vs. cross-unit helper	Positive task interdependence via sharing cross-unit concept maps; sense of competition enhance motivation	Social facilitation and modeling	Personal construction interface; sharing construction interface
3. Evaluate and compare peers' concept maps	Cross-unit	Peer assessor vs. receiver of peer feedback	Help peers revise their work; gain information about other units	Active learning: critical evaluation	Sharing construction interface
4. Construct an integrated concept map	Based on a given unit to link across all units	Active integrator	Based on a given unit for interlinking concepts across all units	Active learning: integrate personal and peers' ideas according to a meta-plan	Sharing construction interface

*Note: See "Primary Interface" section

The term "beyond sharing" refers to combining the features of structuring and competition to achieve the goals listed in Table 1. Many new teachers initially assume that all learning (including listening to lectures) is inherently active. But the preponderance of research over the past few decades suggests that students must do more than just listen — they must actively discover and understand facts through reading and discussion, then transform and construct knowledge by writing or engaging in problem solving (Johnson, Johnson, & Smith, 1998; Moreno & Mayer, 2000). Active involvement means that students must engage in higher-order thinking tasks that entail analysis, synthesis, and evaluation (Turner et al., 1998). BeyondShare promotes active learning by encouraging: a) deep understanding of learning material via concept map construction (what Novak & Gowin [1984] refer to as "meaningful learning"); b) active reflection on the quality of individual constructions through sharing and peer evaluation; and c) the active synthesis of dispersed knowledge by integrating self- and peer-produced constructions (Fig. 4).

Peer assessment

Peer assessment is a widely used strategy in secondary and post-secondary classrooms for teaching principles in such diverse fields as writing, teaching, business, science, engineering, and medicine (Falchikov, 1995; Freeman, 1995; Rada, 1998; Strachan & Wilcox, 1996). The process requires such cognitive activities as reviewing, summarizing, clarifying, giving feedback, diagnosing errors, and identifying missing knowledge or deviations from an ideal (Van Lehn, Chi, Baggett, & Murray, 1995). Receiving abundant and immediate feedback from peers is strongly correlated with effective learning outcomes (Bangert-Drowns, Kulick, Kulick, & Morgan, 1991; Crooks, 1988; Kulik & Kulik, 1988). In conventional classroom settings, teacher feedback may be of higher quality but less frequent and immediate than peer assessments (Topping, 1998). In peer-assessment scenarios, students have more opportunities to view a larger number of projects, allowing them to gain inspiration from concrete examples instead of relying on models centered on a teacher's cognitive skills or knowledge structure. Peer-assessment projects require more on-task time than conventional teacher assessment settings; arguably this is the most important factor in facilitating learning.

Falchikov & Magin (1997), Lin, Liu, & Yuan (2002), and Liu, Lin, & Yuan (2002) are among researchers who state that reliable and valid peer assessment requires three conditions: a) students must fully understand and be committed to the purpose of their assessment activities; b) students need to be involved in the process of determining criteria, rating scales, and assessment procedures; and c) students need to receive feedback on peer-assessment scores in relation to their own performance as well as to the overall score pattern.

The BeyondShare environment

We incorporated concept mapping into the BeyondShare environment as an activity based on the assertions of Novak and Gowin (1984), Roth and Roychoudhury (1992), and others that concept maps are effective tools for knowledge construction. Instead of requiring students to participate in group discussions to create collaborative maps (a process that can lead to unequal contributions), we applied the CCL strategy (Lin, Sun et al., 2002) as a more effective approach to evaluating, synthesizing, and incorporating ideas from maps created by their peers. In implementing this strategy, the learning material must be divided into several units (in this study, three units). As part of the BeyondShare process, final concept map products reflect individual and shared construction efforts that fulfill the requirements of independence and interaction (Katz, 2002). In classrooms that have access to state-of-the-art learning technologies, teachers can use concept map approaches that focus on synchronous (real-time) cooperative behavior (Komis, Avouris, & Fidas, 2002). Although these systems have clear advantages, we purposefully designed BeyondShare with the characteristic of asynchronous distributed learning that we believe is available in a larger percentage of classroom settings.

Primary interfaces

We used a combination of Microsoft Visual Basic 6.0 and SQL Server7 to design two BeyondShare interfaces:

1. A *personal construction interface* that provides a form-based environment. This interface is disabled when students proceed to the sharing construction phase, thereby preventing students from modifying their own concept maps based on the work of others in the same learning unit (Fig. 2). After reading personal assignments for a given learning unit, students begin the personal construction activity in the concept mapping section by pressing the start button (which triggers a time log) and using the construction forms to build and connect self-defined concept nodes with links. A concept map in progress is shown in the current personal concept map section. Concept nodes and linking words are not fixed, giving students greater flexibility for knowledge construction. They use the current personal concept map area to observe and change node positions to revise concept hierarchies. Nodes and linking words can be removed from the storage section once they become irrelevant to the concept map. Students move back and forth between procedures to construct their maps as they see fit.
2. A form-based *sharing construction interface* consists of interlinks among different concept maps. Interlinks differ from links, which connect ideas within individual concept maps. In Figure 3, the bold arrows with dashed lines indicate interlinked connections between two concept maps. Students can use this interface to view their

own completed maps in the personal concept map section. In the modeling section, a system of anonymous selector IDs prevents students from purposefully choosing concept maps made by their friends as favorites. After choosing selector IDs from the other units, students can study maps in their peer concept map sections, then press the start button to begin the sharing construction process. Students can establish interlinks between their own and their chosen maps in the interlinking section and make comments in the feedback section according to a set of reference criteria. As in the personal construction interface, students can delete interlinks displayed in the storage section. The interlinking process consists of selecting single concept nodes from two maps and adding a linking word. Students can establish as many interlinks as they want between concept map nodes.

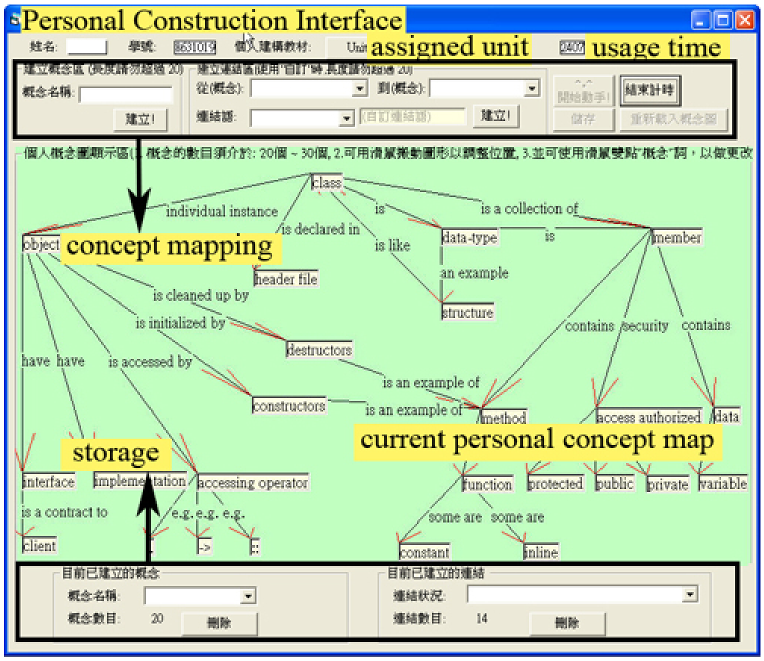


Figure 2. Example of personal construction interface

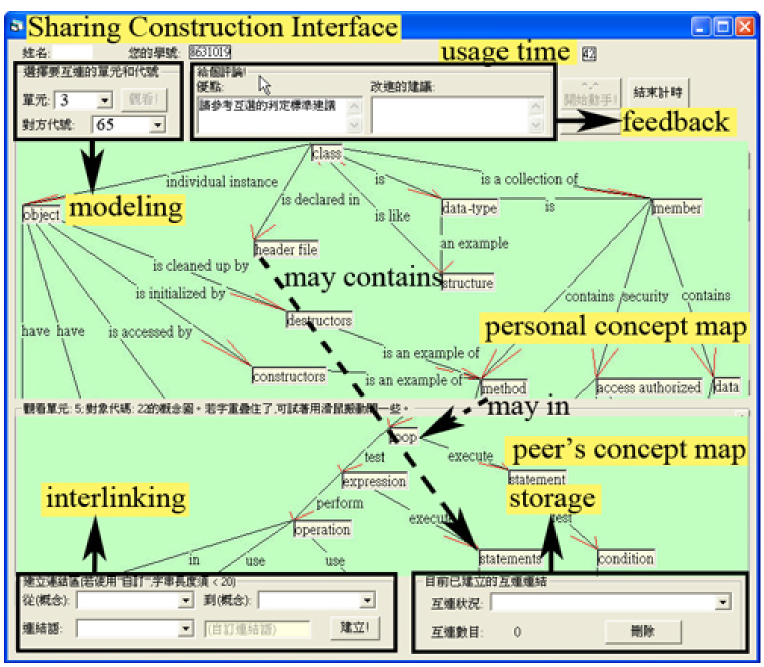


Figure 3. Example of sharing construction interface

During the sharing construction phase, students evaluate all peer concept maps in other units, select "personal best fit" concept maps, and establish interlinks between their own and selected maps. Interlinks can be established between near concept nodes or nodes in remote categories. Links in the latter category are known as "cross-links," implying associations between concepts that many people would not recognize (Novak & Gowin, 1984). In BeyondShare, such links are considered signs of creativity.

Choices for establishing interlinks represent cooperative partner selection — the result of a peer-assessment evaluation process that encourages critical thinking. Sharing and incorporating information across units with cooperative partners are both encouraged; within units, competition is encouraged.

Teacher observation

BeyondShare contains a teacher interface for monitoring student progress, meaning that students who fall behind the learning schedule can be given special attention. The monitor interface presents a student's personal concept map, information on the student's chosen favorites, the number of interlinks between two maps, how much time a student spends on constructing interlinks, and how many other students choose the same map as their favorite. The interface also allows teachers to view information on how many choose the target student's concept map as their favorite, their personal concept maps, and respective interlinks. All preference data can be logged for peer rating analysis.

Evaluating results

After the sharing construction phase is completed, concept maps are arranged in decreasing order of score (number of votes) for each learning unit. The map receiving the most votes within one unit earns the designation of "best fit." Reflective thinking is triggered via comparisons of personal maps with best-fit maps. Furthermore, teachers can construct their own "expert" concept maps for comparison with best-fit maps for two purposes: determining which knowledge structures are acknowledged by the greatest number of students, and helping students make adjustments to incomplete or incorrect concept maps.

BeyondShare evaluation

Participants

A BeyondShare evaluation test was conducted to determine if the beyond-sharing activities successfully engaged students in meaningful learning and knowledge construction. Participants were 34 college freshmen enrolled in an introductory computer science class at a research university in northern Taiwan. Students were randomly assigned to three clusters consisting of 12, 9, and 13 participants, with students in each cluster studying one of three learning units on the topics of function, class, or flow as selected from a C++ textbook. Members of each cluster generated individual concept maps for their assigned unit.

Procedure

We purposefully designed a series of beyond-sharing activities to ensure active learning, positive interdependence, and personal accountability. Using BeyondShare features, cooperative learning was structured by having participants work on a multiple-stage concept-mapping task requiring task interdependence (Table 1). After being grouped according to learning material divisions, students were asked to produce their own concept maps (a task that Novak & Gowin [1984] refer to as "meaningful learning") for their assigned unit and to share their products with peers who worked on other units. Participants were instructed to evaluate, compare, and give feedback for the cross-unit concept maps. Participants therefore contributed to their classmates' tasks by giving feedback while gaining information and knowledge about the other learning units. Based on a meta-plan, participants were asked to link their own maps with the cross-unit maps they selected during the peer-assessment stage to form integrated maps. Participants accepted responsibility for contributing to their cross-unit peers' efforts while competing with same-unit peers. Participant roles switched among active and passive sharers, competitors and helpers, assessors and feedback recipients, and among active integrators, thereby achieving the successful group work components defined by Johnson et al. (1998).

As shown in Figure 4, the evaluation procedure consisted of three stages:

1. Preparation. During week eight of the school semester, students were taught concept-mapping techniques and given several examples for practice. During week nine they were introduced to BeyondShare and its activities, after which they were randomly assigned to one of the three units.
2. Personal construction. During week ten, participants used their class time to create their individual maps. In an attempt to prevent social loafing or duplications of their classmates' efforts, the students were not allowed to view their peers' maps during this stage.
3. Sharing construction. During week eleven, students were allowed to view the concept maps created by classmates assigned to the other units. They were instructed to select one personal best-fit map from each unit and to establish interlinks across units. Participants were explicitly instructed to make their selections in terms of cohesiveness and coherence, and to avoid making their selections based on friendship or exchanges of favors.

At the end of week eleven, students were asked to complete a questionnaire about the BeyondShare environment and their subjective experiences with and perceptions of the beyond-sharing activities.

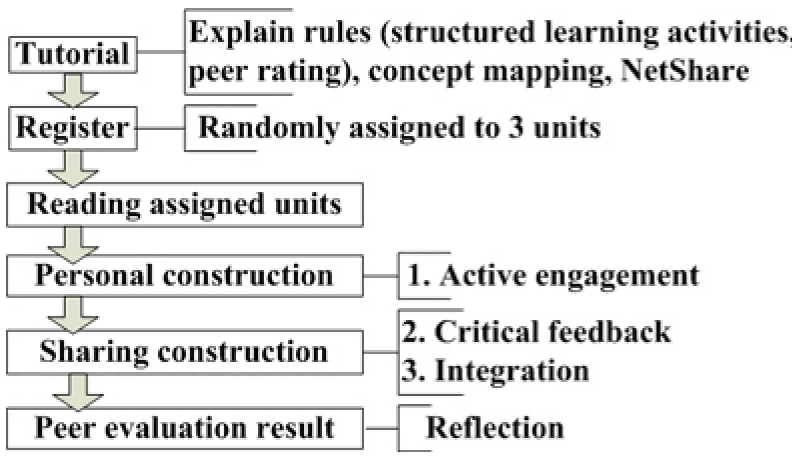


Figure 4. Research flow diagram and three learning formats

Scoring

1. Personal construction peer rating. Concept maps could be selected by peers assigned to other units based on general appearance or a specific task perspective (e.g., the best fit with a student's own work). The number of votes thus represents the degree of cohesiveness and/or coherence between the concepts and structure of two maps. Personal construction scores accounted for 60% of the total peer rating, reflecting our goal of emphasizing personal accountability in active learning.
2. Sharing construction peer rating. Based on evaluations of cohesiveness and coherence, this rating (which accounts for 40% of the peer rating total) represents the number of votes earned by an individual student's favorite maps.

Total peer rating. This is calculated as $0.6 \times \text{personal construction}_{peer} + 0.4 \times \text{sharing construction}_{peer}$.

The proposed peer rating system mimics the system of scholarly journal citations — that is, the more citations (votes) a work gets, the more likely the chosen work is of high quality. However, BeyondShare also takes into account the quality of the selected works. In other words, students must take responsibility for their personal best-fit choices because the scores of their selected maps affect their own final scores. This mechanism reduces the odds of students choosing maps created by their close friends regardless of quality.

Questionnaire

A questionnaire was created to measure the participants' subjective perceptions of BeyondShare and beyond-sharing activities. The first section consisted of six items on interface usability, such as clarity of screen design, function simplicity and helpfulness, and comparative convenience.

Both time-spent and screen-capture records of construction procedures during the personal and sharing construction stages can serve as measures of active learning. However, it is important to note that active learning can take the form of a few meaningful and effective construction steps being produced quickly, or carefully planned cognitive functions emerging over a long time period. We therefore relied on a combination of learning outcomes and questionnaire responses to estimate how many participants felt that they were engaged in active learning and to gather supporting evidence for their responses.

The nine items in the second section focused on student perceptions regarding personal construction (first-level beyond-sharing activity) and approaches to active engagement in meaningful learning. The next six items measured if and how peer assessment (second-level) and competition influenced active engagement in knowledge construction. The final six items recorded student perceptions on sharing construction (third-level) and approaches to knowledge sharing. Responses were measured along a seven point Likert-type scale, with 1 indicating strong disagreement and 7 indicating strong agreement.

Results and discussion

All 34 participants had sufficient time to finish their personal construction projects and to evaluate, select, and integrate ideas from their peers' maps into new, integrated concept maps. Participants needed an average of 2.15 hours to construct their personal concept maps following two one-hour introductions to concept mapping and BeyondShare. Average time spent in the sharing construction process was 1.07 hours. Sample concept maps are shown in Figure 3. Just over one half (53.5%) of the participants reported positive attitudes about the general ease of use of BeyondShare (Table 2). (In this and other tables, boldface indicates data that have been added together and presented as a sum.)

Concept mapping has been criticized for requiring exceptional effort and numerous modifications (Ruiz-Primo & Shavelson, 1996). The questionnaire data indicate that 39.3 percent of the participants regarded concept mapping using BeyondShare as more convenient than using pencil and paper. Negative opinions regarding the procedure were reported by 28.6 percent — an indication that BeyondShare requires revision. Just over two thirds (68%) stated that the personal construction interface was helpful, with 71.4 percent describing the interlink function as easy to use.

Table 2. Student perceptions of NetShare's ease-of-use

	Percentage of respondents						
	strongly disagree				strongly agree		
	1	2	3	4	5	6	7
1. In general, NetShare was difficult to use.	**0.0**	**32.1**	**21.4**	28.6	7.1	10.7	0.0
2. Creating a concept map using NetShare was more convenient than using pencil and paper.	3.6	17.9	7.1	32.1	**17.9**	**14.3**	**7.1**
3. The personal construction interface was clear and its functional guides were helpful.	0.0	0.0	17.9	14.3	**32.1**	**14.3**	**21.4**
4. The personal-construction visual aids were helpful when creating a concept map.	0.0	3.6	14.3	14.3	**14.3**	**39.3**	**14.3**
5. The interlink function procedure was simple and thoughtfully designed.	0.0	0.0	14.3	14.3	**17.9**	**32.1**	**21.4**
6. The system operating description was helpful when I first became acquainted with NetShare.	0.0	0.0	7.1	21.4	**28.6**	**17.9**	**17.9**

Table 3. Student perceptions of personal map constructions (first level)

	Percentage of respondents						
	strongly disagree				strongly agree		
	1	2	3	4	5	6	7
1.Constructing a concept map helped me in memorization.	0.0	3.6	3.6	10.7	**7.1**	**57.1**	**17.9**
2. When constructing a personal concept map, I had a chance to summarize critical points of the material.	0.0	3.6	3.6	7.1	**14.3**	**39.3**	**32.1**
3. I tried to use examples of events or concepts outside of textbooks to clarify the meaning of my concept map.	3.6	7.1	21.4	17.9	**25.0**	**17.9**	**7.1**
4. Constructing a concept map encouraged me to rethink relationships between concepts.	0.0	7.1	0.0	3.6	**17.9**	**42.9**	**28.6**
5. Constructing a concept map helped me organize key points in the learning material.	0.0	3.6	3.6	7.1	**14.3**	**39.3**	**32.1**
6.When constructing a personal concept map, organizing a concept hierarchy encouraged me to rethink knowledge synthesis.	3.6	0.0	3.6	14.3	**21.4**	**25.0**	**32.1**
7. When constructing a personal concept map, I understood some of my shortcomings regarding the learning concepts.	0.0	3.6	3.6	7.1	**17.9**	**50.0**	**17.9**
8. Although concept mapping was beneficial for meaningful learning, I felt it was not worth the trouble.	14.3	35.7	17.9	25.0	**0.0**	**3.6**	**3.6**
9. I am willing to construct concept maps to aid my learning in other courses.	0.0	3.6	7.1	14.3	**17.9**	**28.6**	**28.6**

As shown in Table 3, large percentages of students (50–89%) reported that they had actively engaged in the following cognitive functions:

1. Memorization (item 1): 82.1 percent agreed with the statement that concept map construction is an effective way to memorize learning material.
2. Summarization (item 2): 85.7 percent agreed with the statement that concept map construction gave them opportunities to summarize the most important points of the presented material.
3. Understanding (item 3): 50 percent stated that they used other materials in addition to textbooks when searching for examples that would give them a deeper understanding of a concept.
4. Conceptual organization (items 4, 5, 6): 89.4 percent asserted that drawing a concept map enhanced their comprehension of relationships between concepts, 85.7 percent stated that constructing a concept map helped them organize major concepts, and 78.5 percent agreed that concept hierarchy organization encouraged knowledge synthesis.
5. Reflections on own weaknesses (item 7): 85.8 percent agreed with the statement that drawing a concept map helped them reflect on their deficits, discrepancies, and/or flaws in learning concepts.

Only 7.2 percent of the participating students stated that concept map construction was not helpful in the learning process (item 8). The majority (75.1%) stated a willingness to construct concept maps to facilitate learning in other courses (item 9). We therefore suggest that personal construction (first-level beyond-sharing activity) encouraged student engagement in low- and high-level cognitive strategies and meaningful learning. This result fits well with the active learning and higher-order thinking criteria described by Johnson et al. (1998), Moreno and Mayer (2000), and Turner et al. (1998).

Data on responses to peer-assessment and competition (second-level) items are shown in Table 4. A majority (82.2%) agreed that the peer-assessment procedure helped them learn how to assess concept map quality (item 1) and 82.1 percent agreed that peer concept-map evaluation encouraged them to reflect on properties that a good concept map should possess (item 2).

Most of the participants (75.1%) stated that they were aware of the competitive aspect of BeyondShare and viewed it as motivation to generate better personal construction products (item 3); 74 percent acknowledged that they were expected to compete with their peers for best-fit map votes (item 4). According to these results, the majority of participants were motivated to achieve personal learning goals when constructing quality maps. We suggest that this awareness of competition can reduce social loafing during beyond-sharing activities.

Approximately one-fifth of the participants (18.5%) complained about their maps not receiving votes even though they felt the quality was high (item 5), and 30 percent complained about a lack of satisfaction with their choices (i.e., they felt forced to choose from collections of poorly constructed maps) (item 6). A discussion mechanism such as that integrated by Scardamalia and Bereiter (1991) into their CSILE might help resolve this issue by encouraging modifications that increase map quality and/or coherence.

Table 4. Student perceptions of peer assessment and competition (second level)

	Percentage of respondents						
	strongly disagree				strongly agree		
	1	2	3	4	5	6	7
1.I learned how to assess concept map quality by evaluating and choosing concept maps from other learning units.	0.0	3.6	3.6	7.1	**17.9**	**46.4**	**17.9**
2. Evaluating and choosing a concept map encouraged me to consider the essential features of a "good" map.	0.0	3.6	3.6	7.1	**21.4**	**28.6**	**32.1**
3. Competition with peers to have my map selected as "best fit" for my unit encouraged me to generate a better personal construction.	0.0	7.1	3.6	10.7	**17.9**	**42.9**	**14.3**
4. I tried to gain more votes for "best-fit" concept map by generating a better personal construction.	0.0	7.4	3.7	14.8	**25.9**	**33.3**	**14.8**
5. I felt that the work I did was good, yet my peers did not chose my map as their favorite.	7.4	7.4	14.8	44.4	**11.1**	**7.4**	**0.0**
6. During the interlinking stage, I felt dissatisfied with what I chose as my favorite concept maps.	0.0	14.8	22.2	29.6	**29.6**	**0.0**	**0.0**

Data on the extent to which sharing-construction (third-level) activities helped students achieve active learning using high- and low-level cognitive strategies are presented in Table 5. As shown, the majority (85.7%) viewed the sharing construction activity as an effective means of helping them inspect and model their peers' maps (item 1); 78.6 percent stated that observing their peers' concept maps helped them make improvements to their own (item 2). Over half (57.1%) acknowledged that the sharing process allowed them to summarize key concepts in the chapters they did not work on and therefore gain general knowledge of all learning units (item 3), 57.2 percent agreed with the statement that they had achieved an in-depth understanding of the target material via the sharing construction procedure (item 4), and 64.2 percent agreed that the sharing construction approach was meaningful because it provided opportunities to integrate concepts from different units (item 5). However, 78.6 percent agreed with the statement that it required much effort to create meaningful interlinks between concepts (item 6). In summary, between 57.1 and 85.7 percent of the participating students agreed that the BeyondShare approach encouraged them to use the cognitive functions emphasized by Johnson et al. (1998), Moreno and Mayer (2000), Novak and Gowin (1984), and Turner et al. (1998).

The actively engaged students created high quality concept maps for sharing, offered valid ratings of their peers' concept maps, and constructed coherent global concept maps that integrated ideas from other units. Different combinations of high and low personal and sharing construction scores were used to create the four cells presented in Table 6. High scores indicate that the student's work exceeded the mean. According to the peer rating scores, 38 percent were high active learners (i.e., active in both sharing and personal construction), 29% were active only in terms of sharing construction, and 9% were active only in terms of personal construction. In other words, approximately 75 percent were active in at least one part of the beyond-sharing activities and 25 percent were not active during any part of the BeyondShare evaluation project. According to these results, it was easier for the participating students to actively engage in sharing construction than in personal construction.

Table 5. Student perceptions of sharing construction (third level)

	Percentage of respondents						
	strongly disagree				strongly agree		
	1	2	3	4	5	6	7
1. The sharing construction process allowed me to model my peers' work.	0.0	3.6	0.0	7.1	**25.0**	**35.7**	**25.0**
2. The sharing construction process gave me chances to observe my peers' work in a manner that helped my subsequent work.	0.0	7.1	3.6	7.1	**17.9**	**39.3**	**21.4**
3. The sharing construction allowed me to concentrate on my own work while referring to others' concept maps for quick impressions of the other learning units.	0.0	7.1	17.9	14.3	**21.4**	**21.4**	**14.3**
4. The sharing construction process helped me achieve an in-depth understanding of the learning material.	0.0	7.1	7.1	25.0	**17.9**	**28.6**	**10.7**
5. The sharing construction process, which encouraged me to integrate concepts from different learning units, was a meaningful learning approach.	0.0	7.1	10.7	14.3	**21.4**	**21.4**	**21.4**
6. It was difficult to think of meaningful interlinks between two concepts.	0.0	0.0	0.0	17.9	**17.9**	**28.6**	**32.1**

Table 6. Scores on personal and sharing construction

		Sharing construction scores		Total
		H	L	
Personal construction scores	H	13/34 (38.24%) – A	3/34 (8.82%) – B	16/34 (47.06%)
	L	10/34 (29.41%) – C	8/34 (23.53%) – D	18/34 (52.94%)
Total		23/34 (67.64%)	11/34 (32.35%)	34 (100%)

Conclusion

After defining four types of sharing construction (basic, with notification, with feedback, and with interaction), we proposed a structured method we refer to as beyond sharing to encourage personal integration for active learning. Most current Web 2.0 applications support knowledge sharing or cooperation tools that fit in the four categories. These tools provide rich opportunities for users to experience sharing using various media (e.g., text, photos, music, video clips) or to co-write articles (e.g., Wikipedia). Researchers can utilize these applications as new platforms in order to observe how sharing activities or cooperation evolves in computer-supported cooperative work (CSCW) environments. To achieve the benefits of learning in a CSCW environment, we emphasized its active learning aspects over simple information-sharing activities (although users can benefit from shared knowledge) by adopting a CCL strategy for structuring learning activities (Lin, Sun et al., 2002). By having competition injected into a sharing activity, students are motivated to elaborate on their knowledge for deeper understanding.

We suggest that *BeyondShare* is capable of eliciting active knowledge contributions and empowering users to accumulate knowledge via social construction. Engaging students in active learning was a specific focus of our evaluation test, that is, determining to what extent participants perceived other student maps as information resources and used that information to develop a sense of a learning community via peer assessment. Results from a formal evaluation with 34 Taiwanese college freshmen support BeyondShare's ease-of-use and ability to promote active learning. The same results also indicate that a) students who did not have advanced computer/Internet skills found BeyondShare easy to use; b) the personal construction process helped create a sense of meaningful learning in terms of both low-level (e.g., memorization and summarization) and high-level cognitive strategies (e.g., deep understanding, conceptual organization, and reflection); c) the sharing construction process helped create a sense of meaningful learning in terms of low-to-high level cognitive strategies; d) peer assessment helped foster active learning; e) BeyondShare's competitive aspect was generally viewed as a motivating factor; and f) approximately 25 percent of the participants were not active at all during the BeyondShare evaluation experiment and 75 percent were active during at least one part.

One study limitation is that the sample was relatively small and limited, that is, all students were recruited from a single class at one university. Sampling bias and participant homogeneity could detract from the generalizability of the findings. Researchers may be interested in testing BeyondShare or similar online learning environments with students at different age levels and from a variety of schools, as well as in determining whether the beyond-sharing concept can be applied to tasks associated with skills development, such as programming, graphic design, and web-page design. Others may be interested in using personality inventories such as Big Five Personality Traits (Saulsman & Page, 2004) or 16 Personality Factors (Conn & Rieke, 1994) to identify successful and less successful learner characteristics for beyond-sharing activities.

To our knowledge, BeyondShare is the first learning product aimed at combining the features of structuring and competition, which distinguishes it as an environment that serves an active learning purpose instead of using the Internet to simply share information. BeyondShare also differs from other systems in that it tries to achieve active learning by accommodating cooperation and competition. In other words, students must decide how to use or incorporate parts of their peers' ideas into their own work for a more comprehensive understanding of a topic. During this process of integrating their concept maps with others, students gain a deeper understanding of material across several learning units.

We suggest that teachers interested in using BeyondShare develop comprehensive plans, giving special consideration selecting authentic learning materials to introduce the social construction concept to students, dividing the material into independent but related subtopics, teaching concept map skills, and giving direct instruction on how to use the program. During the personal construction phase, teachers need to closely monitor their students to make sure they adhere to the principles of personal accountability and are not intimidated by competition. During the sharing construction phase, teachers need to encourage peer observation, critical evaluation, sharing, and unbiased peer ratings.

We believe that learning activities should be structured to create a balance between cooperation and competition in order to enhance motivation and learning performance (Johnson et al., 1981; Tauer & Harackiewicz, 2004), but we also acknowledge the difficulty of maintaining such a balance. Teachers may find that some of their students are more focused on competition, indicating a need to emphasize other beyond-sharing activities and benefits. Some teachers may be interested in creating a greater sense of cooperation by asking certain groups to discuss and reach a consensus in terms of interlinks, thereby encouraging the collective consideration of high-quality concept-map properties. In short, teachers are encouraged to experiment with the BeyondShare environment to make learning activities either more competitive or more cooperative. The activities are sufficiently flexible to accommodate these kinds of modifications.

References

Baker, M., Hansen, T., Joiner, R., & Traum, D. (1999). The role of grounding in collaborative learning tasks. In Dillenbourg, P. (Ed.), *Collaborative learning: Cognitive and computational approaches*, Amsterdam: Elsevier, 31–63.

Bangert-Drowns, R. L., Kulick, C. L. C., Kulick, J. A., & Morgan, M. T. (1991). The instructional effect of feedback in test-like events. *Review of Educational Research, 61,* 213–238.

Barron, R. S., Kerr, N. L., & Miller, N. (1992). *Group process, group decision, group action.* Bristol, PA: Open University Press.

Beers, P. J., Boshuizen, H. P. A., Kirschner, P. A., & Gijselaers, W. H. (2005). Computer support for knowledge construction in collaborative learning environments. *Computers in Human Behavior, 21*, 623–643.

Canas, A. J., Ford, K. M., Novak, J. D., Hayes, P., Reichherzer, T., & Suri, N. (2001). Online concept maps: Enhancing collaborative learning by using technology with concept maps. *The Science Teacher, 68*(2), 49–51.

Conn, S. R., & Rieke, M. L. (Eds.) (1994). *l6PF (5th ed.): Technical manual.* Champaign, IL: Institute for Personality and Ability Testing, Inc.

Crooks, T. J. (1988). The impact of classroom evaluation practices on students. *Review of Educational Research, 58,* 45–56.

Edmonds, G. S., & Pusch, R. (2002). Creating shared knowledge: Instructional knowledge management systems. *Educational Technology & Society, 5*(1), 100–104.

Falchikov, N. (1995). Peer feedback marking: Developing peer assessment. *Innovations in Education & Training International, 32*, 175–187.

Falchikov, N., & Magin, D. (1997). Detecting gender bias in peer marking of students' group process work. *Assessment and Evaluation in Higher Education, 22*, 385–396.

Freeman, M. (1995). Peer assessment by groups of group work. *Assessment & Evaluation in Higher Education, 20*, 289–300.

Greenberg, S., & Marwood, D. (1994). Real time groupware as a distributed system: Concurrency control and its effect on the interface. In Furuta, R. & Neuwirth, C. (Eds.), *Proceedings of the ACM CSCW'94 Conference on Computer Supported Cooperative Work*, New York: ACM Press, 207–217.

Häkkinen, P., Järvelä, S., & Mäkitalo, K. (2003). Sharing perspectives in virtual interaction: Review of methods of analysis. In Wasson, B., Ludvigsen, S. & Hoppe, U. (Eds.), *Designing for change in networked learning environments, Proceedings of the International Conference on Computer-Support for Collaborative Learning*, Dortrecht: Kluwer Academic Publishers, 395–404.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (1998). *Active learning: Cooperation in the college classroom.* Edina, MN: Interaction Book.

Johnson, D. W., Maruyama, G., Johnson, R., Nelson, D., & Skon, L. (1981). Effects of cooperative, competitive, and individualistic goal structures on achievement: A meta-analysis. *Psychological Bulletin, 89*, 47–62.

Katz, Y. J. (2002). Attitudes affecting college students' preferences for distance learning. *Journal of Computer Assisted Learning, 18*(1), 2–9.

Komis, V., Avouris, N., & Fidas, C. (2002). Computer-supported collaborative concept mapping: Study of interaction. *Education and Information Technologies, 7*(2), 169–188.

Kreijns, K., Kirschner, P. A., & Jochems, W. (2002). Sociability in computer-supported collaborative learning environments. *Educational Technology & Society, 5*(1), 8–22.

Kulik, J. A., & Kulik, C. L. C. (1988). Timing of feedback and verbal learning. *Review of Educational Research, 58,* 79–97.

Lin, S. S. J., Liu, E. Z. F., & Yuan, S. M. (2002). Student attitudes toward networked peer assessment: Case studies of undergraduate students and senior high school students. *International Journal of Instructional Media, 29*(2), 241–254.

Lin, S. S. J., Sun, C. T., & Kao, G. Y. M. (2002). Designing a networked-sharing construction environment. *British Journal of Educational Technology, 33*(4), 489–492.

Liu, E. Z. F., Lin, S. S. J., & Yuan, S. M. (2002). Alternatives to instructor assessment: A case study of comparing self and peer assessment with instructor assessment under networked innovative assessment procedures. *International Journal of Instructional Media, 29*(4), 1–10.

Moreno, R., & Mayer, R. E. (2000). Engaging students in active learning: The case for personalized multimedia messages. *Journal of Educational Psychology, 92*(4), 724–733.

McCarthy, C., Bligh, J., Jennings, K., & Tangney, B. (2005). Virtual collaborative learning environments for music: Networked drumsteps. *Computers & Education, 44*(2), 173–195.

Mulder, I., & Swaak, J. (2002). Assessing group learning and shared understanding in technology-mediated interaction. *Educational Technology & Society, 5*(1), 35–47.

Mulder, I., Swaak, J., & Kessels, J. (2004). In search of reflective behavior and shared understanding in ad hoc expert teams. *CyberPsychology & Behavior, 7*(2), 141–154.

Novak, J. D., & Gowin, D. B. (1984). *Learning how to learn.* Cambridge, MA: Cambridge University Press.

O'Reilly, T. (2005). *What is Web 2.0: Design patterns and business models for the next generation of software*. Retrieved October 30, 2006, from http://www.oreillynet.com/pub/a/oreilly/tim/news/2005/09/30/what-is-web-20.html

Rada, R. (1998). Efficiency and effectiveness in computer-supported peer-peer learning. *Computers and Education, 30*(3/4), 137–146.

Resnick, M. (1996). Distributed constructionism. *Proceedings of the International Conference on Learning Science, Northwestern University.* Retrieved May 20, 2004, from http://llk.media.mit.edu/papers/archive/Distrib-Construc.html

Resnick, M. (2002). Rethinking learning in the digital age. In Kirkman, G. (Ed.), *The global information technology report: Readiness for the networked word,* Oxford: Oxford University Press, 32–37.

Roschelle, J., & Teasley, S. (1995). The construction of shared knowledge in collaborative problem solving. In O'Malley, C. E. (Ed.), *Computer supported collaborative learning*, Springer-Verlag, Heidelberg, 69–97.

Roth W. M., & Roychoudhury, A. (1992). The social construction of scientific concepts or the concept map as a conscription device and tool for social thinking in high school science. *Science Education, 76*, 531–557.

Ruiz-Primo, M. A., & Shavelson, R. J. (1996). Problems and issues in the use of concept maps in science assessment. *Journal of Research in Science Teaching, 33*(6), 569–600.

Saulsman, L. M., & Page, A. C. (2004). The five-factor model and personality disorder empirical literature: A meta-analytic review. *Clinical Psychology Review*, *23*, 1055–1085.

Scardamalia, M., & Bereiter, C. (1991). Higher levels of agency for children in knowledge building: A challenge for the design of new knowledge media. *Journal of the Learning Sciences, 1*(1), 37–68.

Stahl, G. (2005). Group cognition in computer-assisted collaborative learning. *Journal of Computer Assisted Learning, 21,* 79–90.

Strachan, I. B., & Wilcox, S. (1996). Peer and self assessment of group work: Developing an effective response to increased enrollment in a third year course in microclimatology. *Journal of Geography in Higher Education, 20*(3), 343–353.

Suthers, D. (2005). Technology affordances for intersubjective learning: A thematic agenda for CSCL. *Paper presented at the International Conference of Computer Support for Collaborative Learning*, May 30–June 4, 2005, Taipei, Taiwan.

Tauer, J. M., & Harackiewicz, J. M. (2004). The effects of cooperation and competition on intrinsic motivation and performance. *Journal of Personality and Social Psychology, 86*(6), 849–861.

Topping, K. J. (1998). Peer assessment between students in colleges and universities. *Review of Educational Research, 68*, 249–276.

Turner, J. C., Meyer, D. K., Cox, K. E., Logan, C., DiCintio, M., & Thomas, C. (1998). Creating contexts for involvement in mathematics. *Journal of Educational Psychology, 90*(4), 730–745.

Van Lehn, K. A., Chi, M. T. H., Baggett, W., & Murray, R. C. (1995). *Progress report: Towards a theory of learning during tutoring.* Pittsburgh, PA: University of Pittsburgh Learning Research and Development Center.

Yang, S. J. H., Chen, I. Y. L., & Shao, N. W. Y. (2004). Ontology enabled annotation and knowledge management for collaborative learning in virtual learning community. *Educational Technology & Society*, 7(4), 70–81.