Peer-to-Peer Learning with Open-Ended Writable Web

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ABSTRACT

In spite of advances in educational techonology, most Web-based computer science courses rely on costly pre-made learning materials. By shifting the emphasis to peer-to-peer learning and other student-centred learning principles, more meaningful learning process can be accomplished, without preparing stand-alone Web-courses. A course applying these principles is presented along with a tool built for the purpose. The tool offers the possibility to build a joint information pool and publish new work while constructing knowledge by collaborative annotation of the information or published work. According to our experince, transparency in the learning process is also well-accepted and viewed beneficial by the students.

Categories and Subject Descriptors

K.3.1 [**Computers and Education**]: Computer Uses in Education—*Collaborative learning*; H.5.3 [**Information Interfaces and Presentation**]: Group and Organization Interfaces—*Computer supported cooperative work*; K.3.2 [**Computers and Education**]: Computer and Information Science Education—*Computer science education*

General Terms

Human Factors

Keywords

open learning environments, collaborative learning, joint annotation

1. INTRODUCTION

Even today, when Web-based education has been around for nearly a decade, Web-courses suffer from learning-material centred design and do not utilize the potential of current information and communication technologies. All kinds of gimmicks, such as quizzes or other poorly justified interactive tasks, are normally needed in typical Web-courses to keep up the attention and the motivation of the learners.

Learning-material centred design in a Web-course poses significant challenges to the author of the material. Learning material is and will always be tedious and expensive to prepare, even when existing material is transformed into a Web-course. The costs are easily multiplied if animations, simulations or other meaningful interactive parts are to be included into a Web-course. Yet another issue is the timeliness of the learning material, since most ready-made Web-courses in the field of computer science need to be updated regularly.

One possible solution to address these challenges is to refrain from preparing stand-alone Web-courses. Emerging trends in higher education include a shift from traditional, teacher-oriented lecturing towards *student-centred learning* (SCL), and SCL can be fruitfully exploited also in Web-based education. When simplified, SCL means that communicating course material does not rest solely on the shoulders of a teacher [4] but moves the responsibility of the learning to the students themselves. Therefore, ready-to-use learning material is not a necessity in SCL, thus enabling relatively easy preparation of Web-courses from the teacher's point-of-view. In addition, SCL gives naturally an active role to the students reducing the need to extrinsically motivate the students and use extensive amounts of time to guide or advise each student.

A wide variety of different teaching and learning approaches go under the flag of SCL, e.g. active learning, project-based learning, problem-based learning, case-based learning, and learning by research. Learning tasks in SCL include such techniques as substituting active learning experiences for lectures, holding students responsible for material that has not been explicitly discussed in class, assigning open-ended problems which require both critical and creative thinking, and using self-paced cooperative learning. The research findings of educational literature prove convincingly that properly implemented SCL fosters motivation and elicits a deeper understanding towards the subject being taught [4, 5, 3].

One of the possible learning approaches to SCL is *peer-to-peer learning*. As in other contexts, peer-to-peer activity in learning means resource sharing, active communication, forming learning communities in shared information spaces and building trust and social relationships between peers.

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Typically, peer-to-peer networks are informal, thus requiring self-directed learning. When integrating SCL and peer-to-peer learning into Web-based education, key to the success is that the tools used, the course structure and the assignments are designed to support student-centred peer-to-peer learning activities accordingly. As seen in several research reports, student-centred principles by large can be seen as essential building blocks for computer-supported collaborative learning [12, 1], but peer-to-peer learning has not been extensively used in higher education. The paper describes an example how a course in advanced computer science was built to support SCL and peer-to-peer learning, and presents a tool used in the course. The tool is called EDUCOSM and it was designed for the purpose. Especially useful features in the tool for supporting novel ways of collaboration include an open-ended document pool to serve as the learning material, and annotations to documents that are visible to every course participant.

2. STUDENT-CENTRED LEARNING PROCESS FOR THE COURSE

2.1 Learning process

The modern psychological and educational theoretical perspectives are based on the assumption that a learner is an active contributor in the individual learning process [14]. In addition, she needs support and facilitation to find her capacity and empower herself as a learner. The concept of empowerment is defined in the context of this study as "a synergistic interaction among individuals, which emphasizes cooperation and leads to expansion of power for the group" [8]. The central idea is that learners need to think for themselves and take responsibility for their own learning in collaborative learning situations.

One of the most important learning goals today is to cope with the vast amount of information. The students are expected to be able to search, process and publish information, and be capable of critically evaluate published work. Searching for resources leads to a common pool of relevant information, but questions arise concerning the pool of information. Which is the most relevant information for the assignments given? For one document, which are the most relevant issues? What have I understood and/or misunderstood? A successful learning process needs critical thinking abilities and ways to evaluate critical thinking. Normally, course structures do not support active learning [11] or empowerment explicitly. The learning process supported by appropriate tools and teaching arrangements has an important role in promoting empowerment and facilitating learning processes towards self regulation and active contribution in social contexts.

Sears and Marshall [13] argue that empowerment is created and realized by individuals themselves, not given or handed down by someone else. The important psychological processes which lead towards empowerment are self-regulation, self-determination and self-efficacy [6]. These concepts are based on the social cognitive view of motivation and cognition.

In addition to self-monitoring, social learning communities, which promote collaboration and knowledge creation in partnership with other learners, are needed. Such learning environments should enrich distributed cognition and provide mediated learning experiences. Vygotsky [15] shares with Feuerstein [7] the Hegelian philosophical idea of mediated activity where symbols and the means of their transmission become mediative agents. In mediated learning, human interaction is fundamental to the learning process. The goal is to get students to monitor and regulate their own learning. Teachers, tutors and peer learners are needed to increase students' understanding and self-criticism that leads to successful learning results. The learner's knowledge creation as a social process with other learners creates a learning culture in which students' potential to empower one's learning is supported.

From the student's perspective, the learning process becomes more meaningful if everyone does not have to reinvent the wheel every time. This can be achieved if the learning process can be made transparent for everyone so that the students can benefit from each other's work in peer-to-peer fashion. One example of this process goes as follows. The process starts with searching relevant information from various sources. The search is guided by the assignments or instructions given during the course. After the search each student processes the information, and produces and publishes an outcome (e.g. written report). The outcome is exposed to the students and teachers alike, and at this stage, feedback from peers and possibly from the teacher guide the process. The process continues by refining the work and publishing updated versions for scrutiny, or searching new information and starting the process from the beginning, depending on the learning tasks set for the course. At the end of the course, the community of learners has built a vast stack of knowledge, covering the topic from different perspectives.

The challenge is to extend the possibilities of peer-to-peer collaboration also to searching, selecting and processing information, not only to discussion of published work.

2.2 Course setting

The above-mentioned learning process was put to use in an advanced computer science Web-course named "Adaptive educational systems". The form of the course was a seminar, which means that every student must pick a topic and prepare an oral presenatation and a written paper on it. The tasks in the course, in chronological order, were:

1. Search for material consisting of research reports or other scientific resources which serve as a common ground for the course topic, and form an overall picture of the field
2. After getting acquainted with the material, choose one or two articles and prepare a summary of them, and publish the summary for comments
3. Prepare a short oral presentation about the topic as an introduction for a roundtable discussion
4. Refine your topic and prepare a draft of the final paper, publish the draft for comments (optional), and after refinement, publish the final version of the paper.

Course grading was agreed to have four components: written paper, oral presentation, discussion and commenting, and overall activity during the course. The written paper constituted 35% of the final grade, the oral presentation 15% (relying solely on peer-assessment), discussion and

commenting 25%, and overall activity 25%. Overall activity included number and quality of articles found and the time spent in the learning environment.

Twenty-four students participated in the course. The course lasted a total of six weeks. The students were computer science majors at graduate and undergraduate level. They were familiar with computers and felt at ease with the tool used.

The course included only two face-to-face meetings. During the first meeting the course structure was explained and the details of the course execution including the grading policy were agreed upon together with the students. The tool used in the course was also explained. The second face-to-face meeting was the roundtable-discussion lasting four hours, giving each student roughly ten minutes for the presentation and discussion.

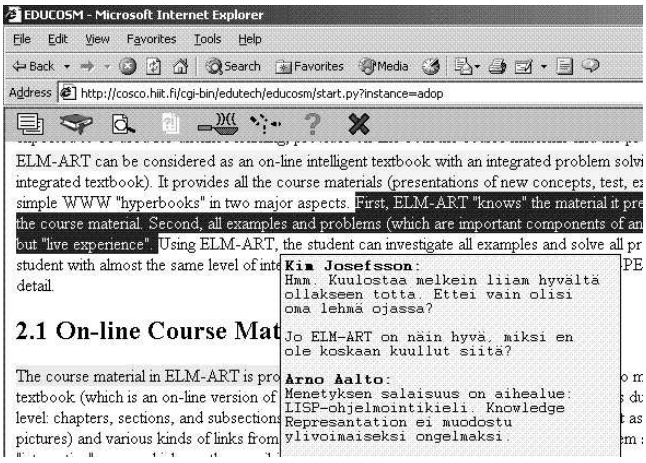

Figure 1: An annotated document with highlighted sentences and a commented sentence with two annotation comments in one tooltip.

3. EDUCOSM TOOL AND ITS USE

3.1 Tool description

The EDUCOSM tool used as a course platform was designed to support peer-to-peer learning in a collaborative setting. The most important issue in the tool is the transparency that penetrates the operation of the tool altogether; everything is visible to everyone else present, so that the students can benefit from each other's actions. This leads to a form of *social navigation* [10, 2], i.e. the actions of others guide the learning process for each individual.

The first operation of the tool is the ability to bring arbitrary Web-documents to the course area, i.e. to build an open-ended common collection of resources together with the other students of the course. When a student finds an interesting document from the Web (while logged-in to the system), bringing the document into the course area requires right-clicking the mouse and selecting "Add to EDUCOSM" from a pop-up menu. True to the nature of peer-to-peer networks, it does not matter where on the Web the document is located. The document is then added to the collection of course resources, and is there for everyone to utilize. The document is not copied but only linked and indexed into the system to avoid copyright issues.

The most innovative operation included in the tool is collaborative annotation of *any* Web-page brought into the course area. When a course participant is viewing a document, he or she can highlight or comment an arbitrary part of the text. The annotations are visible to all users. In practice, highlighting is performed by selecting a part of the text with the mouse, right-clicking the mouse and selecting "Highlight" from the pop-up menu. When someone places the mouse pointer over a highlighted text, a tooltip is presented telling who has made the highlighting (Fig. 1). Similarly, a comment to a specific part of the text can be done by selecting the text fragment, right-clicking the mouse and selecting "Comment" from the pop-up menu. Another pop-up is opened where the user can enter the comment. The comment is visible as a tooltip to everyone who places the mouse pointer over the text with a comment (Fig. 1).

The way the annotations are visible for every participant has significant consequences. First, seeing others' actions adds to the sense of not being alone in a Web-course, noted as an important issue in Web-based learning [9]. Second, collaborative annotations help people to jointly process information and show others what they have viewed as important or otherwise meaningful issues, and what kind of questions are raised by the material and what could be the answers.

When people are actively annotating documents, the documents can easily be flooded with highlights and comments. Therefore, EDUCOSM offers filters for viewing only the highlights and comments of the desired participants. Everyone can create as many filters as needed. The filters are created easily by selecting the desired participant names from a list. This way a student can read the document without any annotations, or can view only annotations from the student group he or she belongs to.

Since the space for a comment or comments in a tooltip is eventually limited, every user can initiate a document-specific newsgroup-type hierarchical discussion for more deep or thorough discussions around the document. When a user is viewing a document that does not have an attached newsgroup, the user can start a discussion with a right mouse-click and selecting "Add newsgroup".

EDUCOSM also includes a "desktop", which shows links to course announcements and assignments as well as up to five relevant recently-added documents and newsgroup postings. The document and newsgroup lists are individually adapted to every user by simple heuristic rules.

Of course, EDUCOSM incorporates also an extensive search option, where the search can be extended to documents, annotations, or newsgroup postings. Relevant documents can also be bookmarked for convenience.

3.2 Results from the tool use

One of the central ideas of the pedagogical approach used was that there was no pre-made material compiled by the course teacher, but the students had to find relevant sources of information by themselves. A total of 136 documents were accumulated during the course, 65 of which were articles written by research groups and other outside authorities (called *background articles* from now on). The remaining 71 documents were students' own contributions, published by the students themselves during the course. The number of background articles added by individual students varied between 0 and 17, the average being 2.7. About 77% of the

background articles were added during the first 2 weeks of the course, and the rest of the documents were added to the system somewhat evenly during the remaining 4 weeks. Active reading and annotation continued throughout the period. After the initial wide-spread search for information related to the course, the students seemed to be exploring the available material gradually, elaborating on the topics they found interesting.

The students relied primarily on the commenting function for communication. 693 comments were written in total, as opposed to only 82 newsgroup postings. It seems that messages attached directly to text fragments are in many situations preferable to more separated communication channels. Highlightings were also used heavily for marking critical sections of the documents. The students created 1484 highlightings, making it significantly easier for others to find the important information.

It can be seen that some documents were more meaningful than the others by looking at how many annotations the documents solicited from the participants. Figure 2 illustrates the differences between documents in terms of the number of annotations they received. 18 of the 136 documents were not annotated at all, and 55 documents had fewer than 10 annotations. On the other hand, the most extensively annotated document had 121 annotations, and 24 documents had more than 25 annotations. When evaluating the relevance of the documents to the course needs, it is appropriate to consider also the length of the documents, which we measured in terms of word count. The number of annotations per 100 words varied between 0 and 8.15, with an average of 1.49 and standard deviation of 1.97. As expected, 44 of the 50 most densely annotated documents were summaries and papers written by the students.

The students were generally active, although significant differences were found among the participants. The amount of comments ranged from 0 to 159, and the the amount of newsgroup postings varied from 0 to 31. Highlights varied from 1 to 343. Also the time spent on the system varied heavily (131 minutes to 2987 minutes, sessions over 30 minutes cut-off to 30 minutes).

Since there were only 24 students attending the course, there was not a real need to use filters to avoid excessive annotation. Only 9 students created their own filters, and the log data indicates that they were just experimenting with the system rather than actually using the filters. Questionnaire results indicate that most of the students did not find filters useful, but one student stated that "when I wanted to really understand the document, I turned off the annotations to be able to read the 'clean' document". The document pool was also so small that only 3 students used the internal search function more than 5 times. Again in the questionnaire results, it was mentioned that the total number of documents added "was just in the limit that can be handled as a list". However, both the filter and the search functions may turn out to be useful when the system is used at a larger scale.

Students had no trouble using the system in meaningful ways. For example, most of the students published their work early and tried to get helpful comments from others. Even though the available time for publishing drafts for final papers was very short (11 days), one student published four different versions, updated based on the comments from the others.

4. CONCLUSIONS

An important learning objective for higher education is the ability to deal with information from various sources. When the learning process and course constructs are built to support this objective, students become more independent in their learning, the teacher's role diminishes, and no separate learning material needs to be prepared. In other words, learning becomes student-centred.

When using the whole World-Wide Web as a learning resource, appropriate tools have to be used so that the learning task is not overwhelming. EDUCOSM supports collaborative learning efforts by making the actions of others visible to everyone else. These actions include collecting information to a common pool, annotating the information with highlights or comments, starting discussion on a topic, and publishing own contributions to the peers to collaborate on.

The course employing above-mentioned principles and tools showed that the students enjoy the transparency where they are helping each other, even though the course grading does not directly support it. The course structure also omitted one approach often present in student-centred learning, namely working in peer groups. Student motivation and learning outcomes could have been enhanced if small-group work had been included, although the course in fact required group work in a group consisting of all course participants, in a true peer-to-peer learning fashion.

5. REFERENCES

[1] C. Bonk and D. Cunningham. Searching for constructivist, learner-centered and sociocultural components for collaborative educational learning tools. In C. Bonk and K. King, editors, Electronic Collaborators: Learner-Centered Technologies for Literacy, Apprenticeship, and Discourse, pages 25–50. Lawrence Erlbaum, 1998.

[2] A. Dieberger. Social navigation in populated information spaces. In A. Munro, K. Höök, and D. Benyon, editors, *Social Navigation of Information Space*, pages 34–54. Springer, 1999.

[3] M. Dillinger. Learning environments: The virtual university and beyond. In F. Tschang and T. D. Senta, editors, *Access to Knowledge - New Information Technologies and the Emergence of the Virtual University*, pages 1–14. Pergamon Press, 2001.

[4] R. Felder and R. Brent. Navigating the bumpy road to student-centered instruction. *College Teaching*, 44:43–47, 1996.

[5] R. Felder and R. Brent. Effective strategies for cooperative learning. *Journal of Cooperation & Collaboration in College Teaching*, 10(2):69–75, 2001.

[6] D.M. Fetterman. Foundations of empowerment evaluation. Sage Publications, 2001.

[7] R. Feuerstein. Instrumental enrichment: An intervention program for cognitive modifiability. Baltimore Univeristy Press, 1980.

[8] R. Herrenkohl, G. Judson, and J. Heffner. Defining and measuring employee empowerment. *Journal of Applied Behavioral Science*, 35(3):379-389, 1999.

[9] J. Kurhila, M. Miettinen, P. Nokelainen, and H. Tirri. EDUCO - a collaborative learning environment using social navigation. In P. de Bra, P. Brusilovsky, and R. Conejo, editors, *Adaptive Hypermedia and Adaptive*

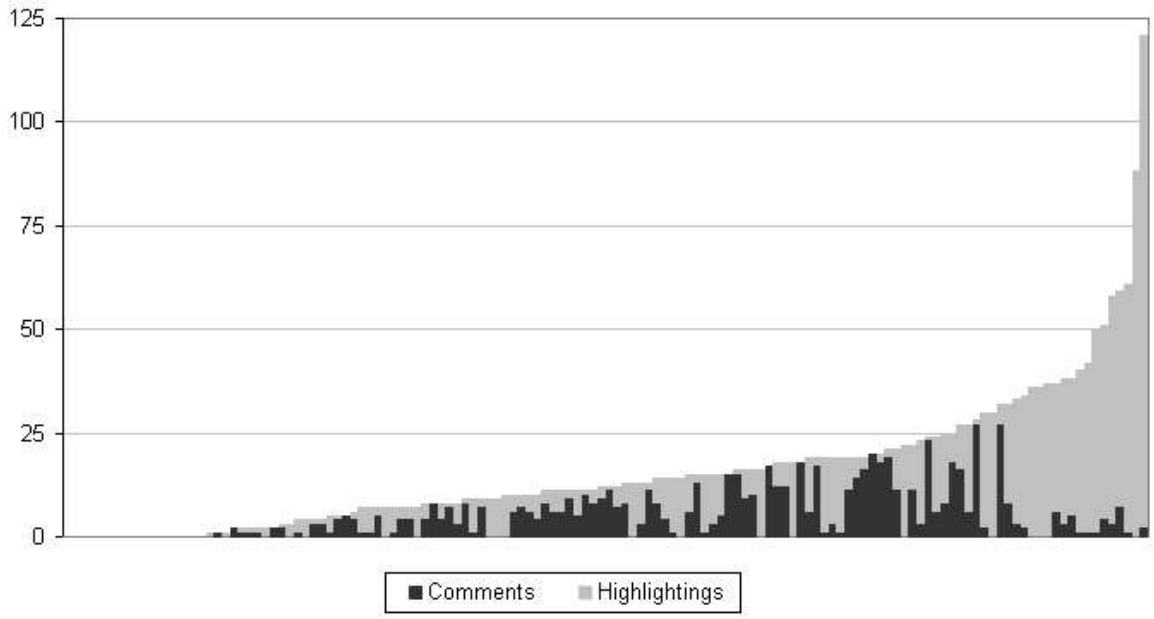

Figure 2: Amount of annotations per document with highlights and comments separated.

Web-Based Systems (AH 2002), LNCS 2347, pages 242–252. Springer, 2002.

[10] A. Munro, K. Höök, and D. Benyon. Footprints in the snow. In A. Munro, K. Höök, and D. Benyon, editors, *Social Navigation of Information Space*, pages 1–14. Springer, 1999.

[11] P. Ramsden. Learning to Teach in Higher Education. Routledge, 1992.

[12] M. Scardamalia and C. Bereiter. Computer-Support for Knowledge-Building Communities. *The Journal of the Learning Sciences*, 3(3):265–283, 1994.

[13] J.T. Sears, and J.D. Marshall. Teaching and thinking about curriculum: critical inquiries. Teachers College Press, 1990.

[14] R.E. Snow, L. Corno, and D. Jackson. Individual differences in affective and conative functions. In D.C. Berliner, and R.C. Calfee (Eds.),*Handbook of educational psychology*, Simon & Schuster & MacMillan, 1994.

[15] L.S. Vygotsky. Mind in society: The development of higher psychological processes. Harvard University Press, 1978.

[16] H. Wang and Y. Chee. Supporting workspace awareness in distance learning environments: Issues and experiences in the development of a collaborative learning system. In C.-H. Lee, editor, *International Conference on Computers in Education/Schoolnet 2001*, pages 1109–1116, Seoul, Korea, 2001. Incheon National University of Education.