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A shared document-based annotation tool to support learner-centered collaborative learning

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Abstract

A shared document-based annotation tool was presented, and its usefulness in two different real-life web-based university-level courses (adult learners, n=27 and adolescent learners, n=23) was empirically investigated. The study design embodied three data collection phases: 1) a pre test measuring self-rated motivation, learning strategies, and social ability, 2) log file data analysis showing actual use of the system features, and 3) a post test in a form of an email survey. For both groups the results showed that the level of motivation has a positive effect on activity in the system and the final grade. The learners, who reported to have good time management strategies, were the most active users of the system. The level of social ability predicted both number of consecutive comments in documents and threads in document-related newsgroup discussions. Log file data analysis showed that user activity in the system was positively related to the final grade in both samples. Results of the post test showed that all the respondents agreed when asked a) if the system brought added value to the learning process, b) if the use of the system changed their studying habits favourably, and c) if they would like to use the system in other courses.

Introduction

This study was conducted in order to present a shared document-based annotation tool, EDUCOSM (Kurhila, Miettinen, Nokelainen, Floréen and Tirri, 2003). In this study we empirically evaluate its usefulness in two different real-life web-based university-level courses with both adult and adolescent learners. Furthermore, we investigate how learner's self-rated motivation, use of learning strategies, and social abilities are related to cognitive outcomes (final grade) and completion of various tasks (on-line group formation and peer-to-peer annotation of the course material) in the system.

First we take a look at existing shared annotation systems and discuss about our approach to learner-centered collaborative learning. Next we describe the EDUCOSM system and the research methods applied in this study. Finally, we present the results and concluding remarks.

Theoretical framework

Shared Annotation

There exists a large research body studying both personal and collaborative annotations in several domains. Previous research (Marshall, 1997) has shown that annotations made in books are useful to subsequent readers. We categorize annotation systems into two main groups: Document-centered and discussion-centered. Discussion-centered systems providing tools to browse and annotate discussion messages and threads are out of the scope of this paper. Next we discuss about non-commercial document-centered systems where learners are able to browse and annotate web-based documents.

The first generation of annotation tools such as ComMentor (Roscheisen, Mogensen and Winograd, 1994) and Group Annotation Transducer (Schickler, Mazer and Brooks, 1996) required installation of platform-specific client-side software. The second generation allowed annotation of any document on the Web. Systems like CoNote (Davis and Huttenlocher, 1995) showed annotations embedded in the document, at the nearby position that they were made.

We see two problems with the first and second-generation annotation tools: First, annotations are separated from the context visually by placing them into different browser frame or window, and second, annotations are not embedded in the document at the exact position that they were made. Some of the third generation creditable annotation systems, such as Kukakuka (Suthers and Xu, 2002), concentrated on design for artefact-centered discourse, ignoring the first issue of annotation context. We agree that there is no problem with long and threaded newsgroup discussion-like annotations, but we argue that simple one or two word comments should be placed in the context that elicited them. In the EDUCOSM system, user made annotations are shown in small tool tip windows that pop up on top of annotated area. Background colour of the area indicates the type of annotation: straw-coloured stands for highlighting and light green stands for comment.

The second problem was answered by some of the third generation of annotation tools, such as CritLink (Yee, 1998) and Annotation Engine (Seltzer, 2000). Both systems allow embedded annotations, but CritLink places markers around annotated text phrase indicating exact sphere of influence, as Annotation Engine generates just one pointer for each annotation. Both systems allow anyone to add annotations to any document on the Web. EDUCOSM continues this development process introducing numerous intuitive features such as document highlighting and commenting with right clicking the mouse and selecting desired text area.

Learner-centered learning

Throughout the 1990's learner-centered learning environments (SCLE) and computer-mediated communication (CMC) systems such as problem-based, project-based, cognitive apprenticeships, constructivist learning environments, and goal-based scenarios, have rather focused on the affordances they provide learners for effecting their way of learning and thinking, than transmitting information from teachers to learners (Land and Hannafin, 2000).

Learner-centered learning is supported theoretically by various overlapping pedagogical concepts such as self-directed learning (Candy, 1991), learner-centered instruction or learning (Felder and Brent, 1996), active learning (Ramsden, 1992), vicarious learning (Lee and McKendree, 1999) and cooperative learning (Felder and Brent, 2001). For example, self-directed learning involves

dimensions of process and product referring to four related phenomena: personal autonomy, self-management, learner-control and autodidaxy (Candy, 1991). All these dimensions are present in the process of learner-centered learning where the locus of control is shifted from teacher to the learner who has now a greater responsibility for her own learning.

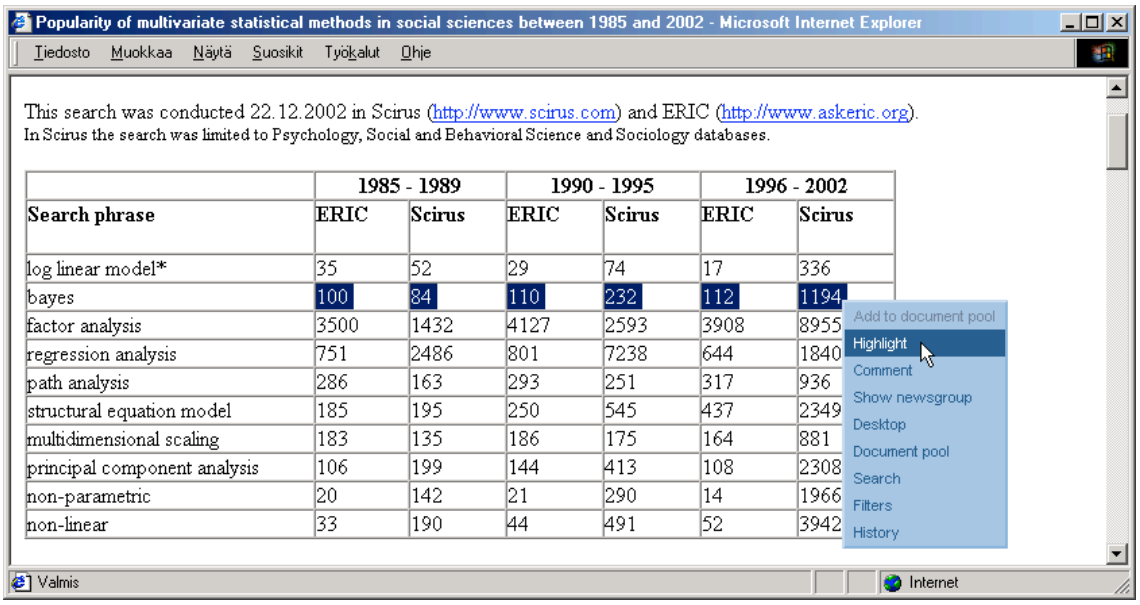
The research field of computer-supported collaborative learning (CSCL) has three theoretical views on collaborative technology: (1) learner-centered principles, (2) constructivism, and (3) sociocultural theory (Bonk and Cunningham, 1998). The learner-centered principles (APA, 1997) present a similar shift from the traditional teacher-centered approach to learner-centered approach of instruction providing learner with valuable real-life skills (Dillinger, 2001).

Learning tasks in learner-centered learning environments include such techniques as substituting active learning experiences for lectures, holding learners responsible for material that has not been explicitly discussed in class, assigning open-ended problems and problems requiring critical or creative thinking, and using self-paced and/or cooperative learning. The research findings of educational literature prove convincingly that properly implemented learner-centered learning fosters motivation and elicits deeper understanding toward the subject being taught (Felder and Brent, 1996; 2001; Dillinger, 2001).

The idea of learner-centered collaborative learning in the context of this study is that learners are expected to take responsibility for their own learning: The instructor gives an orientation to the topic through theoretical face-to-face lectures. S/he also gives few pointers to selected on-line resources. The system provides tools to process information and collaborate with peer learners. The system allows the user to add new, and read existing html-documents published in the Internet. The users annotate the documents by highlighting and commenting selected target areas. Same target area is open for multiple annotations, allowing users to communicate asynchronously via annotations.

The EDUCOSM system

The system appears to the user as a popup menu that is opened by clicking the right mouse button anywhere in the browser window. The menu options appear as follows: “Add to document pool”, “Highlight”, “Comment”, “Show newsgroup”, “Desktop”, “Document pool”, “Search” and “Filters”. Each document has its own newsgroup that is activated when first message is written. The idea is that short conversations should take place in comment windows, but the longer ones should continue in the document specific newsgroup. User is able to search for text phrases from the documents that are brought into the system, and also from the newsgroup messages attached to documents. (Figure 1.)



	1985 - 1989		1990 - 1995		1996 - 2002	
Search phrase	**ERIC**	**Scirus**	**ERIC**	**Scirus**	**ERIC**	**Scirus**
log linear model*	35	52	29	74	17	336
bayes	100	84	110	232	112	1194
factor analysis	3500	1432	4127	2593	3908	8955
regression analysis	751	2486	801	7238	644	1840
path analysis	286	163	293	251	317	936
structural equation model	185	195	250	545	437	2349
multidimensional scaling	183	135	186	175	164	881
principal component analysis	106	199	144	413	108	2308
non-parametric	20	142	21	290	14	1966
non-linear	33	190	44	491	52	3942

Figure 1: User adding a highlighting to a document in the EDUCOSM system

Filters enable user to restrict visibility of other user annotations. User may also create his/her own filters, for example, for group work purpose. Desktop is the "index page" of the system containing four areas: Announcements, assignments, documents and newsgroups. Figure 2 shows user reading a comment made by the course lecturer.

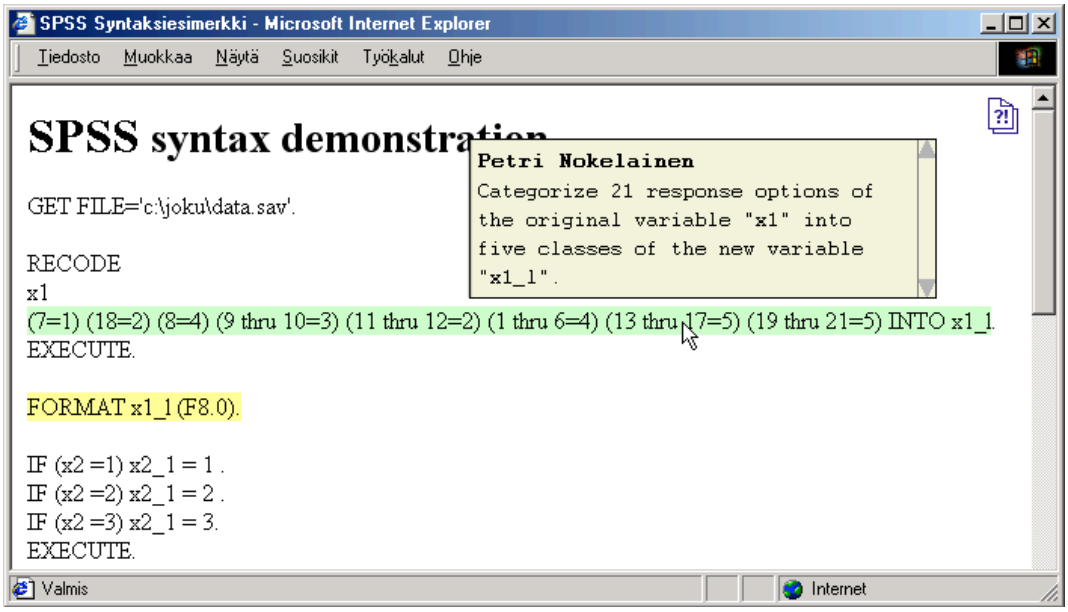


Figure 2: User reading a comment in the EDUCOSM system

An example of a standard task for the students participating in a quantitative educational statistics course utilising the EDUCOSM system is as follows:

1. Find a scientific study report from the Internet that applies quantitative methodology.

2. Add the document into the systems document pool.
3. Read and annotate (by highlighting and commenting) the document.
4. Write approximately 2000 word report analysing the use of statistical methodology in the study.
5. Publish the report in the system.
6. Select one other students report in the system and comment both the contents and the annotations made by the peer-learner.

In order to complete the task, user needs to search for relevant documents published in the Internet. The search function of the system has three options: 1) Internal search engine, 2) Google and 3) manual navigation. The last one is useful if the user prefers to use other search engine than Google. In that case s/he may enter the URL manually. When the desired document is open in the browser window, the user may right mouse click anywhere in the window and choose from the opening popup menu "Add to EDUCOSM". The document is then visible in the system and open for annotations and internal search for all users.

The documents are not copied to the EDUCOSM server to avoid copyright problems. The system consists of a collection of server-side CGI-scripts and an HTML and JavaScript based client that runs inside a standard web browser. The role of the server is to store data and act as a proxy between the client and the rest of the web. The server attaches annotations and newsgroup messages to the documents as they are retrieved from their original locations. In addition to annotations and newsgroup messages, user profiles, and various statistics regarding the activities of the users are stored in the server.

Method

The motivation to use two different samples in this study is two-fold: First, we examine if shared document-based annotation serves for both master's degree and post graduate university level studies, and second, we are interested to see if there is difference between adolescent and adult learner's subjective satisfaction with the system.

Sample 1: Adult post-graduate students

The sample consisted of 23 female and 4 male Finnish vocational education inservice teachers (n=27) participating in a web-based university-level statistics course in Fall 2002. The respondents were taking their post-graduate degree. Their age range between 21 and 51 years (median 38 years).

Sample 2: Adolescent master's degree students

The sample consisted of 20 female and 3 male Finnish university students (n=23) participating in a web-based adaptive hypermedia course in Fall 2002. The respondents were taking their master's degree. Their age range between 21 and 49 years (median 24 years).

Pre test

Information about motivation, use of strategic skills in learning and social abilities was gathered with a self-rated on-line questionnaire system, EDUFORM (Nokelainen, Niemivirta, Kurhila, Miettinen, Silander and Tirri, 2001). The questionnaire (Ruohotie, 2002; Ruohotie and Nokelainen, 2002) contained 27 items measuring three dimensions of professional learning: (1) motivation, 12 items; (2) learning strategies, 10 items; and (3) social abilities, 5 items. The

response options varied in a five-point Likert-scale from "1 - Completely Disagree" to "5 - Completely Agree".

The motivation category (Pintrich, Smith, Garcia and McKeachie, 1993; Ruohotie, 1999; Nokelainen and Ruohotie, 2002) consists of three sections: (1) a value section, (2) an expectancy section, and (3) an affective section. The value section has three subscales: (1.1) intrinsic goal orientation, (1.2) extrinsic goal orientation, and (1.3) meaningfulness of study. The expectancy section consists of two subscales: (2.1) control beliefs and (2.2) self-efficacy. The affective section includes one component: (3.1) test anxiety. The learning strategies category (Pintrich, 2000; Ruohotie, 2000; Martinez, 2001) consists of four sections: (1) metacognition in learning; (2) metacognition in practice; (3) learning by doing; and (4) resource management. The social abilities category consists of two sections: (1) interpersonal and intrapersonal abilities (Tirri, K., Komulainen, Nokelainen and Tirri, H., 2002); and (2) self-concept (Marsh and O'Neill, 1984). The descriptive statistics presented in Table 1 show that the two samples come from quite different populations as profiles differ from each other statistically significantly in every third proposition (11 out of 33). The statistical analysis was made with non-parametric Mann-Whitney test.

Table 1: Initial statistics and structure of the pre test questionnaire

Proposition	*Mean (S.D.)*	*Mean (S.D.)*
Motivational category	Sample 1	Sample 2
1. I prefer to study demanding subjects from which I can learn something new.	4.2 (0.9)	4.2 (0.8)
2. I am able to learn even the most difficult subjects if I use good study methods.	3.9 (1.1)	4.2 (0.7)
3. I expect to get excellent grades in my vocational/occupational studies.	2.9 (0.9) *	3.5 (0.6) *
4. I am confident that I understand even the most difficult aspects of my studies.	2.9 (1.0) ***	3.8 (0.7) ***
5. I want to receive as high grades as possible.	3.2 (1.1)	3.1 (1.0)
6. In examination situations I am also concerned about the other questions that I cannot answer.	2.1 (1.1)	2.0 (0.7)
7. I am very interested in my field of study as well as in the new information related to it.	3.7 (0.9)	4.1 (0.8)
8. I am really nervous in all test situations.	2.7 (1.3)	2.3 (0.9)
9. I find it most rewarding when I can research a subject as thoroughly as possible.	3.7 (0.9)	3.7 (0.8)
10. I believe that my university/vocational studies will be of practical benefit to me.	4.6 (0.8) *	4.0 (1.0) *
11. If I do not understand theory, it is because I am not trying hard enough.	3.4 (1.3)	3.5 (1.0)
12. It is important for me to do well in my studies and show others what I am capable of.	2.3 (1.1)	2.4 (0.9)
Learning strategy category		
13. I use the time for studying efficiently.	3.8 (0.9) **	3.0 (0.8) **
14. I set goals for learning in order to direct the course of my studies.	3.7 (0.9)	3.2 (0.9)
15. I work hard in order to pass my courses even if I did not like all the readings and exercises.	3.8 (0.9)	3.5 (0.6)
16. I learn best through practice.	4.3 (0.8)	4.1 (0.8)
17. Before reading a new text I first glance it through and see how it is outlined.	4.1 (0.6) *	3.4 (1.2) *
18. During exercises I ask myself questions and ponder on the relation between theory and practice.	3.8 (1.0) *	3.0 (1.2) *
19. I seldom have time to go through notes and review literature before an exam.	3.3 (1.2)	3.2 (0.9)
20. I learn most from practical training.	3.9 (0.9)	3.6 (0.9)
21. I try to elaborate on my own thoughts based on what I have been taught.	3.8 (0.8)	3.6 (1.0)
22. I want to receive performance-related feedback from my teachers.	3.8 (1.0)	3.7 (0.9)
Social ability category		
23. Even in strange company, I easily find someone to talk to.	4.1 (0.9) **	3.3 (1.0) **
24. I get along easily with different types of people.	4.5 (0.6) **	3.8 (0.9) **
25. In negotiations and group work, I am able to support the group to find a consensus.	4.3 (0.5) **	3.7 (0.8) **
26. I can place myself to a situation of another people in group work situations.	4.3 (0.7)	4.0 (0.8)
27. I can manage my emotions in group work situations.	4.1 (0.8)	4.0 (0.6)

* The mean difference is significant at the 0.05 level (2-tailed).

** The mean difference is significant at the 0.01 level (2-tailed).
*** The mean difference is significant at the 0.001 level (2-tailed).

Log data

User log from the EDUCOSM system was recorded during the courses from September 27 to December 1, 2002. The data file contains parameter values for numerous user activities, for example, individual time spent annotating and reading documents, number of highlightings, comments and newsgroup messages.

Post email survey

An email survey consisting of seven open propositions was conducted three weeks after the two courses in November (sample 1) and December (sample 2) 2002. We received responses from 21 participants, 11 from the first sample and 10 from the second sample. Propositions measured users experiences and expectations towards computer supported education together with attributes related to the system.

Course structure

After two face-to-face sessions covering selected theoretical issues, the course relied following two weeks solely on peer-based distance learning in the system. During this time, learners were expected to (1) form a group of two, and (2) annotate by highlighting and commenting an on-line document. The group mate was selected anonymously amongst the other available learners with a special tool. Only personalization information provided in the dynamic selection process was the motivation, learning strategy and social skill profile presented for each learner. In addition, the group mean was reported for each dimension to help decision-making. Each group worked anonymously on a different document, brought into the system by the course lecturer. The learning task had following phases: (1) establishing a newsgroup for the document, (2) highlighting and (3) annotation the relevant issues in the document, and (4) discussing about the document with peer learner in the newsgroup.

Research questions and design

The research questions and their operationalization are presented in Table 2.

Table 2: Initial statistics and structure of the pre test questionnaire

Research question	Operationalization								
	Sample		Pre test			Log data	Post test	Learning outcomes	
	1	2	Motiv.	Learn. str.	Soc. abil.	Activity in the system	Open-ended questions	Quality of annotations	Final grade
1. How differences in profile information predict learning outcomes?	o	o	o	o	o			o	o
2. How users actions in the system predict learning outcomes?	o	o				o		o	o
3. Is the shared document-based annotation tool useful for learning?	o	o					o		

Design of the study is presented in Figure 3.

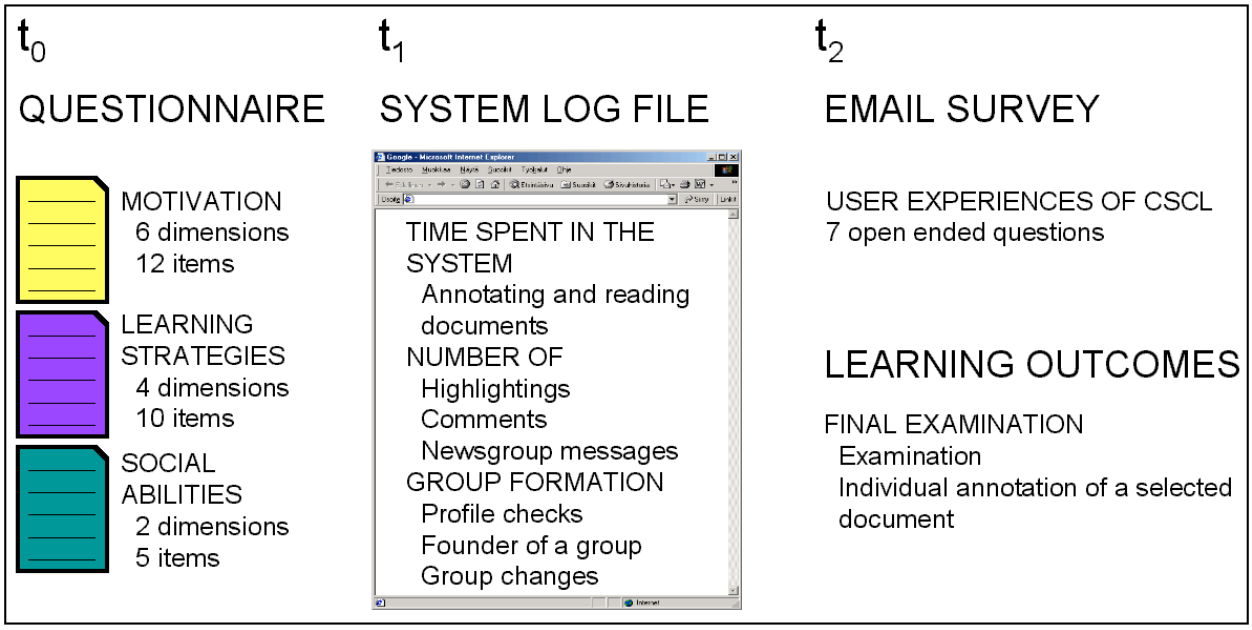


Figure 3: The study design

Results

Various dependencies between variables produced from the questionnaire, log file data and e-mail survey were investigated. Statistical analysis was conducted with non-parametric correlation and Bayesian network modeling (Myllymaki, Silander, Tirri and Uronen, 2002) due to small sample size and the fact that we could not guarantee multivariate normality assumption. Next we discuss the main results separately for the two samples, adult and adolescent learners.

Sample 1: Adult post graduate learners

Results show that self-rated level of motivation, item 12 "It is important for me to do well in my studies and show others what I am capable of", had a positive effect on final grade ($r = .435$, $p = .023$*). Self-rated need for performance-related feedback from the teacher or tutor correlated negatively with observed activity in the system ($r = -.501$, $p = .008$**). High metacognitive abilities, item "21. I try to elaborate on my own thoughts based on what I have been taught", correlated positively with the final grade ($r = .430$, $p = .025$*). Those who reported in the pre test their social ability level to be high, did not make the first move in group work situations, for example by highlighting the document ($r = -.684$, $p = .003$**). Further, we found evidence that study success was positively related to the learner's activity in the system ($r = .528$, $p = .005$**).

Sample 2: Adolescent master's degree students

Those students who found it most rewarding to research a subject as thoroughly as possible were the most active annotators in the course ($r = .458$, $p = .028$*). Students' self-rated metacognitive abilities, item 13 "I use the time for studying efficiently", had a positive effect on both quality of annotations ($r = .567$, $p = .005$**) and activity in the system ($r = .692$, $p = .000$***). Practically oriented learners in this sample were the least active users of the system ($r = -.478$, $p = .021$*). Quality of annotations in the system correlated positively strongly with activity in the system ($r = .893$, $p = .000$***) and final grade($r = .786$, $p = .000$***).

Post email survey

The seven open email survey propositions, coded manually into three categories (disagree, agree, strongly agree), are presented in Table 3. Results of the survey showed that all the respondents agreed when asked if the system brought added value to the learning process. They also agreed if the use of the system changed their studying habits favourably, when compared to their previous studies. All the respondents agreed, when asked if they would like to use the system in other courses, too. Highlightings made by other learners was the most annoying feature of the system. It was interesting to see, that all the respondents reported that comments made by other learners promoted their learning in some ways.

Table 3: Results of the e-mail survey

Proposition	*Disagree N (%)*		*Agree N (%)*		*Strongly agree N (%)*	
	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
1. The study process in the system has added value when compared to traditional studying.	- (-)	- (-)	- (-)	3 (30)	11 (100)	7 (70)
2. The use of the system changes my studying process when compared to my previous studies.	- (-)	- (-)	5 (45)	3 (30)	6 (55)	7 (70)
3. The system would be useful with other courses.	- (-)	- (-)	1 (9)	1 (10)	9 (82)	9 (90)
4. The self-made highlightings promoted my learning.	- (-)	1 (10)	5 (45)	3 (30)	6 (55)	6 (60)
5. The highlightings made by other learners promoted my learning.	2 (18)	1 (10)	6 (55)	5 (50)	3 (27)	4 (40)
6. The self-made comments promoted my learning.	- (-)	1 (10)	2 (18)	3 (30)	9 (82)	6 (60)
7. The comments made by other learners promoted my learning.	- (-)	- (-)	8 (73)	4 (40)	3 (27)	6 (60)

Concluding remarks

A shared document-based annotation tool (EDUCOSM) was presented, and its usefulness in two different real-life web-based university-level courses was empirically evaluated. The process of employing groups of adult and adolescent learner's self-rated motivation, learning strategies, and social ability profile into collaborative learning tasks of an on-line learning environment was investigated.

The profile information for each learner was obtained from a 27-item questionnaire, and stored into the system. The system consists of a set of asynchronous collaborative knowledge constructing tools. Both courses had several group work assignments, where learners were expected to form a group of two, and annotate by highlighting and commenting an on-line document.

The over-all results of the pre test and log file data analysis showed that the self-rated level of motivation has a positive effect on activity in the system and the final grade. The learners who reported to have good time management strategies, were the most active users of the system. The level of social ability predicted both number of consecutive comments in documents and threads in document-related newsgroup discussions. Log file data analysis showed that user activity in

the system was positively related to the final grade in both samples. Quality of annotations correlated positively strongly with the final grade in the adolescent sample.

Results of the post test showed that all the respondents agreed when asked a) if the system brought added value to the learning process, b) if the use of the system changed their studying habits favourably, and c) if they would like to use the system in other courses. In addition, all the respondents reported that comments made by other learners promoted their learning in some ways. Highlightings made by other learners was found to be the most annoying feature of the system.

This real-life use of the EDUCOSM system showed that shared document-based annotation promisingly supports learner-centered collaborative learning. However, further studies are needed to investigate possible distractive effects of peer-to-peer annotation to individual learning processes. For example, self-made highlightings and comments were experienced to be more useful, than those made by other learners.

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