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"Theory Repositories" via the Web for Problem-Based Learning

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ABSTRACT

This paper describes a series of experiments conducted at the School of Management Studies at the University of Twente designed to improve students' concentration on the theoretical study materials in a particular course. In 1997 a problem-based learning approach was introduced into a course on organization theory. After the first year it was apparent that acquisition and application of the theoretical principles of the course by student groups was below expectation. In an attempt to remedy this problem, a Web-based collaborative work environment was introduced in 1998 with the intention of encouraging students to read relevant theoretical material and also to reflect more on what they had read, via writing notes about the materials and making these available to others in their group. The collection of reflective documents is called a "theory repository" (King & Star, 1990). In addition to hosting a theory repository, the collaborative work environment was designed to control the flow of work and to enforce rules for groups' access to the output of other groups, based on their own performance. Further changes were made after the evaluation of the 1998 cycle and a third version of the course was run and evaluated in 1999. A description of the educational setting and of the Web-based collaborative work environment and its theory repository is presented. The three editions of the course are described and the evaluation results over the period 1997–1999 are presented and discussed. The extent to which the discipline of reading improved is evaluated, as are the effects on insight into theory. The evaluation shows that the technical realization works well, but uptake of the instructional tasks for reflection only takes place if these tasks are perceived by the students as being pertinent to their performance in terms of assessment in the course.

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EDUCATIONAL SETTING

The Management Science course "People, Technology, and Organization-II" (called MTO-2) is taught each year to 150–200 undergraduates at the University of Twente in the Netherlands. This 200-hour course focuses on organization theory and its relevance for designing business organizations. Since 1997, a problem-based learning approach has been adopted (Barrows & Tamblyn, 1980) with the intention of activating and motivating the students through participation in realistic case studies. The students work in project groups each consisting of six or seven students. Over a period of 10 weeks the groups study theory and work on exercises which involve predefined case studies. The theoretical component consists of a textbook (currently, Daft, 1998) and three sets of eight theoretical articles. The case studies address a number of organizational issues in car manufacturing. Parallel to the group work, there are a number of class sessions with small groups of around 40 students. In these sessions the student groups present their findings, after which discussion takes place moderated by an instructor. The final mark for the course is a combination of the individual mark for the textbook-based examination and the group mark for the report on the case study.

Problems in the 1997 Course

The 1997 course was evaluated by Smit and van Riemsdijk (1998), who demonstrated flaws in the theory part of the group work. The instructors had hoped for a higher level of knowledge and skills than were displayed by the students at the completion of the course. Reading of theoretical articles in pairs, for instance, though prescribed, did not take place. Furthermore, in many groups there was insufficient transfer (Vygotsky, 1978) of what students had read individually to other group members. This resulted in sparse use of relevant theory in the case-study exercise reports written by the groups. Following this evaluation, the School of Management Studies considered using some form of Web support as a possible means of helping to stimulate the reading of theoretical articles through monitoring of deliverables, and of helping to improve reflection on theory by offering the students the option to read each other's work. A requirement was that any Web solution developed should be as efficient as possible for the instructors, contributing no addition to the quantity of paper-based deliverables in the course, and preferably no extra instructor workload. The first question investigated in our experiments was:

How can Web support help stimulate the use of theoretical materials in case-study exercises in an efficient way?

Redesign of the 1998 Course

A website was set up in 1998 with the aim of building up a "theory repository" and stimulating the students to read theoretical articles and reflect on issues of theory. The division of reading tasks was left to the groups. For each of the 24 articles on organizational theory, every group had to submit a reflective contribution which targeted the core of the article. This contribution took the form of two questions about the article, together with a model answer for each question. The contributions of a group form a group resource. The set of contributions on a particular article form a resource for all groups. The latter resource was only made accessible to another group after that group had submitted a serious contribution on that same article themselves. The basic quality assessment (group contribution is "not ok" or "ok") was performed by teaching assistants, also through the website. The students were asked to rank the submissions of other groups, indicating per article which five contributions they judged to be of the highest quality. This top-five exercise was intended to further enhance reflection on theory. The instructor was thus able to monitor the students' discipline of reading, assuming that a submitted contribution was indeed related to a thoughtful reading of an article. The planned relation between the learning goals and the different work forms is given in Table 1.

In addition to Web support for theory-related purposes, a shared-workspace facility was made available. This was expected to be useful for the groups when working between course meetings. The shared workspace allows file

Table 1. Relating Course Components and Learning Goals.

	Course component		
Learning goal	Theory and Web-support	Class sessions	Group work and discussion
Knowledge acquisition	++	–	–
Improving insight	+	++	+
Application of theory in problem-solving	–	+	++

++ primary goal.
+ secondary goal.

uploading via a browser, so that all members of a group can access and use the same set of files. We wanted to see if our students needed this sort of telematic support, or if they preferred to rely on other means of sharing information. So the second question of interest to us was:

Is a shared-workspace facility useful for our on-campus students?

Revisions to the 1999 Course

Based on the experiences of 1998 and the evaluation which accompanied the course, revised setups for the website and for the instructional tasks were introduced in 1999. Instead of questions and model answers, groups were now asked to contribute one short 10-line summary per article. The summaries of each group formed a collection that the groups could use in their sharing of expertise. Ranking was now included in the grading by teaching assistants (group contribution is "not ok", "ok" or "excellent"). Instead of an obligatory top-five assignment, the students were now offered the option to read a small number of excellent summaries by other groups, again only after a serious contribution on that same article by the group themselves. The goal of this redesigned cross-group exchange of expertise was to stimulate more efficient

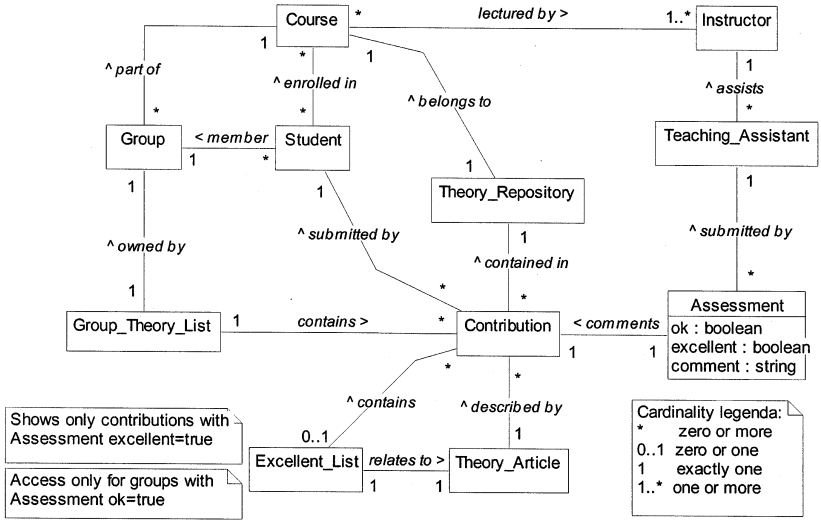

Fig. 1. UML class diagram of the 1999 version of the "theory repository". Directionality of relations is indicated by ^, < and >.

reflection on theory. The main concepts involved in the 1999 course design, and the relations between them, are shown in Figure 1 in the form of a UML class diagram (Larman, 1998). As an example of how to read the diagram we focus on the "Student" concept. In this setting, the student is a member of *one* "Group", he or she is enrolled in *zero or more* "Course(s)", and *zero or more* "Contribution(s)" can be submitted by a certain student.

Web Support for the 1998 and 1999 Courses

In this section, we describe the 1998 and 1999 Web support in more detail. The technical implementation was based on using Microsoft Internet Information Server as the Web server. Group contributions were stored in an MS-Access database. Active Server Page (ASP) scripting implemented the writing to and querying the database.

To limit access to resources to only those groups who had made a proper contribution, the membership mechanism of the publically available groupware package, BSCW (Basic Support for Collaborative Work, 1998) was used in the 1998 course. After each assessment those groups entitled to access were granted membership to those workspace folders containing the HTML file making a call to the database. The groups could also use BSCW workspaces as a group archive if they wished. As this method turned out to be time-consuming and error prone, the access mechanism for 1999 was integrated into the ASP solution that was developed for 1999.

Because the operating system (Windows NT) does not provide a hierarchical group mechanism, a dedicated user administration add-on was set up (Veen et al., 2000). This solution permits the formation of groups at the course- and project-group level via a Web browser, as well as the assignment of roles and accompanying privileges. When students log onto the course site a personalized screen is presented, offering only those options currently accessible to that user plus some personalized status information (see Fig. 2). (In contrast, in 1998 students had been presented with a screen showing all articles, including those to which they had not yet earned access rights. This had led to frustration for students when attempting to access non-accessible articles.)

The ease of use of the 1999 website was improved by counting the number of required keystrokes and mouse clicks for basic actions like "reading group contributions", "reading contributions of other groups", and "assessing contributions" (Card et al., 1980) in the 1998 site. The results were used to shorten the sequences in the 1999 redesign.

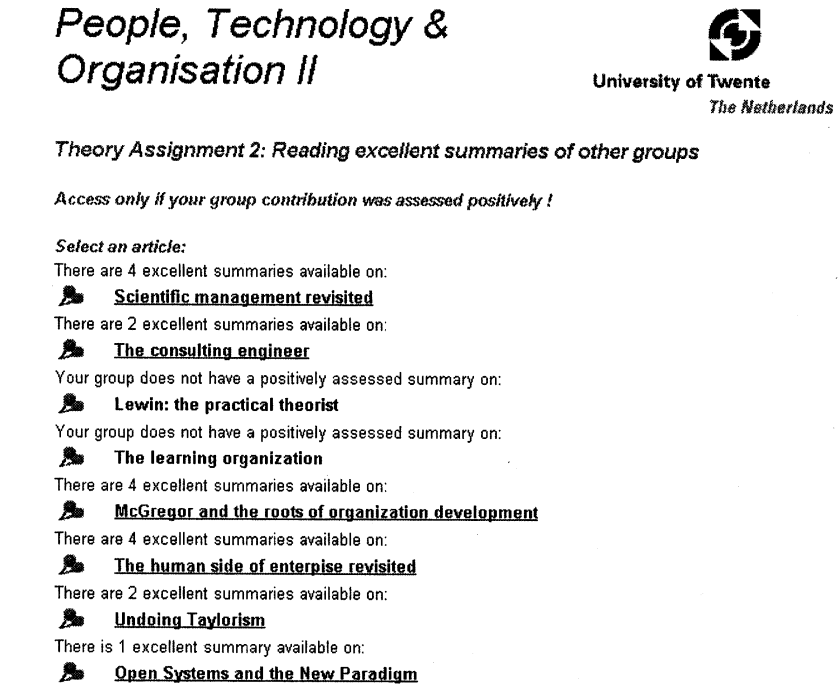

Fig. 2. Example of a personalized screen in the 1999 course offering the student access to six out of eight listings of excellent summaries by other groups. Access depends on group performance.

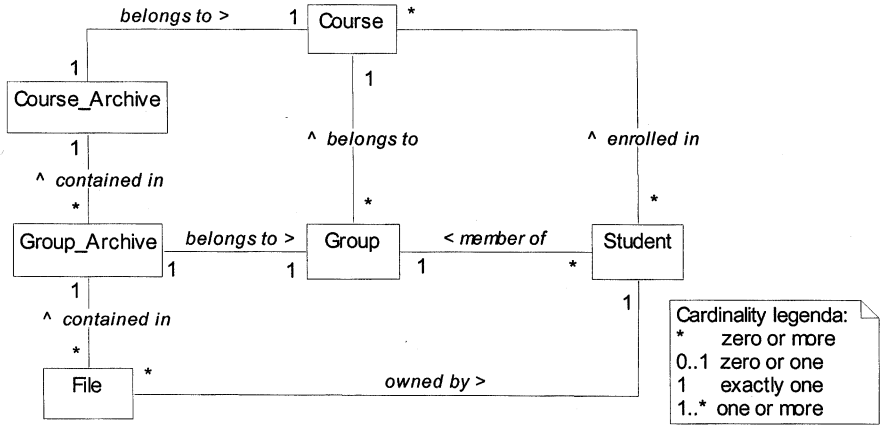

Fig. 3. UML class diagram of group archives as implemented in the 1999 course edition.

In addition to the theory repository, each group was automatically assigned a folder on the server for file archiving. Figure 3 illustrates the relevant concepts relating to access of these files by means of a UML class diagram. Only members of a group have full access to the files in that group's archive. Files can be uploaded via a browser. Post-upload processing checks file size and, as a security precaution, allows only "safe" file types to be uploaded.

The two group archive solutions (1998 and 1999) are shown in Figures 4 and 5. Apart from the omission of many functions in 1999 compared with the 1998 solution, it is apparent that the 1999 user interface is more in line with the rest of the website.

EVALUATION APPROACH

This experiment can be considered as a time-series case study in a natural setting. The 1997 course had no Web support and that year's evaluation data can

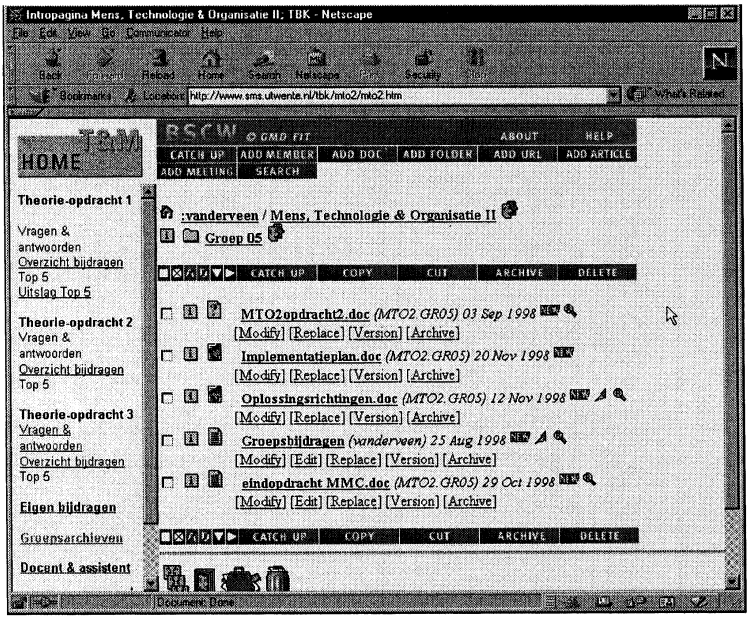

Fig. 4. Group archive solution (in Dutch) for 1998 using Basic Support for Collaborative Work (BSCW, 1998). A group archive containing five files is shown in the main frame next to the menu.

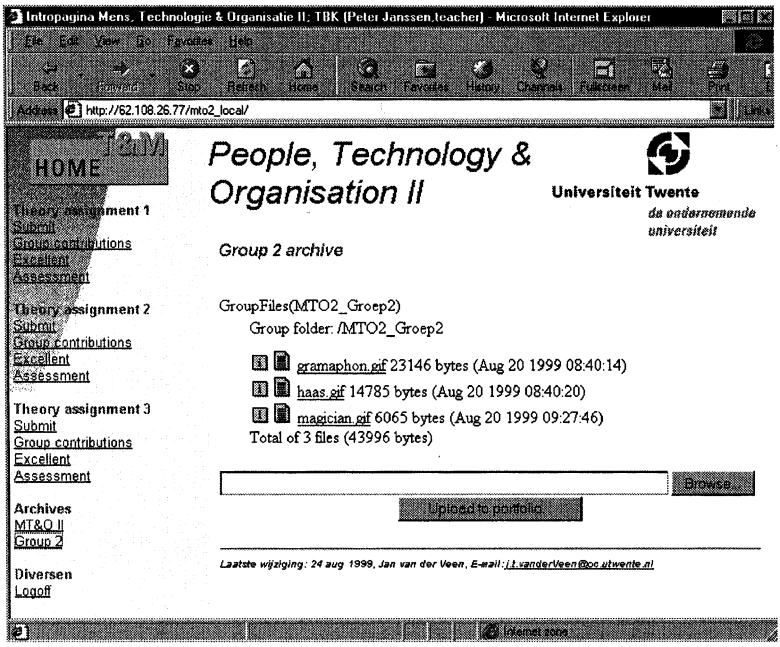

Fig. 5. Group archive solution for 1999 using an Active Server Page solution. A group archive containing three files is shown in the main frame next to the menu.

be used as a baseline. In 1998 Web support was introduced. Finally, in 1999 the Web support was modified as described above. As this time-series evaluation of the course over a three-year period involves different groups of students, some characteristics of the groups were checked (see Table 2). It appears that in all three years the students are predominantly male. Most students have entered the university directly after finishing their secondary school career. Their computer literacy level is high. A study into the use of e-mail and the WWW at our university (Bakx, 1998) shows that 90% of the students use e-mail frequently. The World Wide Web is used frequently by 80% of the students, using facilities both at home and at the university.

The main goal of the implementation, and therefore the main evaluation questions, involves the value of the website in improving reading discipline (Q1, Table 3). Reading was assumed to have taken place when a group member had submitted a contribution through the website. Improvement of insight was thought to be reinforced by realizing a number of instances for reflection through

Table 2. Year Group Characteristics of the Management Science Students (Peters, 1998).

Year	Number of students	Percentage of female students	Percentage of students directly from secondary school
1997	168	17	92
1998	183	19	92
1999	164	24	92

cross-group reading of other groups' work (Q2). The planned-for reflection was hopefully perceived as being helpful by the students (Q3). The optional use of the group archive was evaluated to see if students would use and appreciate this type of Web support (Q4). Also, we looked for indicators of improved student results (Q5). The perceived ease of use of the website (Q6) was checked to see if minimal conditions for proper use were met. Evaluation data were gathered in different ways. Quantitative data were gathered by analyzing the course grades, the database contents with respect to the numbers of submitted contributions, the percentages of approved contributions, and the number of logged reading events. Student questionnaires were filled in by students of all three course versions so that we could check for significant changes over the years. The instructors and a student panel were interviewed to elicit open-ended comments on the versions of the course. The triangulation strategy (Stake, 1995) is given in Table 3, indicating for each of the questions the primary source of information, as well as additional sources of evaluation data.

RESULTS

In this section, we will discuss the results of the experiments per question as defined in Table 3. In the discussion we will comment on the overall conclusions and possibilities for future improvements of the instructional design that was supported by the website.

Question 1: Does the Theory Repository Help Improve the Discipline of Reading Theory?

We assume that the number of submitted contributions is an indicator of the discipline of reading. Table 4, item 1, indicates that, for most of the 24 articles, contributions were submitted in 1998. In 1999, groups submitted 27 summaries,

Table 3. Evaluation Questions and Evaluation Methods.

Question	Primary source	Additional source(s)
Q1 Does the theory repository help improve the discipline of reading theory?	Database analysis	Student questionnaire Student interview
Q2 Are students reading other groups' work?	Database analysis	Student questionnaire Student interview
Q3 Is reading other groups' work perceived as helpful by students?	Student questionnaire	Student questionnaire Student interview
Q4 Did students use the group archives?	Database analysis	Student questionnaire Student interview
Q5 Does the website improve student results?	Instructor interview	Course grades Database analysis
Q6 Was the website easy to use?	Student questionnaire	Keystroke analysis

compared to an average number of 23 submissions in 1998. This increase was caused mainly by groups submitting revised summaries in 1999 after having received a "not ok" assessment for earlier submissions. The teaching assistants approved 67% of the contributions in 1998, versus 68% of the contributions in 1999, see item 2 in Table 4. The percentage of "excellent lists" for which groups received access is higher in 1999 (76%) compared to 1998 (65%), see item 3 in Table 4. This was caused by the additional submissions in 1999.

Most students indicated on the questionnaire that they needed more than 30 minutes to read an article. In the interview some students stated that they could now easily monitor whether each student had performed his or her reading task. The interdependence of group members on each others' performance is clear. We conclude that some discipline of reading has been enforced and can now be monitored. The level of improvement with respect to 1997 is unclear, as no exact data on reading articles that year are available.

Question 2: Are Students Reading Other Groups' Work?

We used the log mechanism in the evaluation of the use of all collected contributions by other students. Questionnaire results (see Table 5) and interview

Table 4. Group Means and Standard Deviations for Contributions Submitted through the Websites.

Database statistics	1998 $n=28$	1999 $n=23$	Significance 1999 versus 1998
1 Number of contributions per group	23 ± 4 min=13, max=29	27 ± 4 min=22, max=36	**
2 Percentage of approved contributions	67 ± 12 min=46, max=83	68 ± 8 min=54, max=82	n.s.
3 Approved contributions per group as % of 24 articles	65 ± 15 min=33, max=100	76 ± 12 min=54, max=96	**
4 Number of times other groups' work was read	11 ± 5 min=3, max=24	64 ± 40 min=13, max=160	***
5 Number of files stored in the group archive	2 ± 6 min=0 (23×), max=25	20 ± 17 min=0 (1×), max=64	***

n.s. = not significant; ** = significant at 0.01 level; *** = significant at 0.001 level

outcomes were used to find out more about why they did or did not use this option. In 1998 the event-log mechanism showed a total of 309 reading events, an average of 11 events per group. The number of events decreased with time when the (unpopular) top-five assignment was cancelled. In 1999 this number rose to 1,465[1] reading events, an average of 64 events per group (item 4, Table 5). Whereas in 1998 only one event per group per article was logged at the most, in 1999 an average of four individual group members were logged using the option to read excellent summaries.

As opening a contribution does not necessarily imply reading it, an estimate of the reading time was made by comparing time stamps of consecutive reading events as far as they are related to the same user. Taking into account only consecutive reading events with time stamps that differ by 30 minutes at the most, we could analyze 900 reading events from the 1999 data. The average reading time was 97 seconds (± 200 seconds). Because of an asymptotic tendency caused by several long intervals, the median of 37 seconds seems a better estimator of the reading time than the mean. This 37 seconds may seem short, but it turns out to be sufficient for a (fast) reading of a 10-line summary in which the student is interested. The score on item 1 in Table 5 confirms our analysis that significantly more students in the 1999 version of the course were

1. The actual number of reading events is higher, as the logging mechanism was only available from the fourth week of the course.

Table 5. Comparing Means and Standard Deviations for Student Questionnaire Items Relating to Appreciation of the Website.

Student questionnaire	1998 $n=83$	1999 $n=110$	Significance 1999 versus 1998
1 I always read the contributions on other articles.	1.97 ± 1.10	3.37 ± 1.42	***
2 If I wanted to submit data through the website, it was clear how to do this.	4.15 ± 1.00	4.45 ± 0.91	*
3 On the website, I had a good overview of what was finished, and what was still to be done.	3.52 ± 1.21	3.66 ± 1.16	n.s.
4 It was fun to work with the website.	2.35 ± 1.12	3.03 ± 1.12	***

1 = disagree, 5 = agree, n.s. = not significant; * = significant at 0.05 level; *** = significant at 0.001 level.

reading work from other groups. For reading work of fellow group members a median interval of 60 seconds was found, based on 552 logged reading events.

In the evaluation interview of the 1999 course, students indicated that they read the excellent contributions to get information about the content of the different articles, to see how other groups are doing, and to get an indication of what an excellent summary should look like. Students preferred to read just the excellent summaries instead of all the summaries, because this would take too much time. We conclude that most students did use the option to read other groups' work.

Question 3: Is Reading Other Groups' Work Perceived as Helpful by Students?

The 1998 evaluation results (van der Veen et al., 1999) showed that, although the discipline of reading theoretical articles had been enhanced, the students felt that the formulation of questions and model answers did not help them very much in their group work. The students reported that, after finishing this assignment, they still had not done the summaries for their group. The top-five assignment was felt to be "a waste of time", as reading sometimes more than 20 contributions on the same article was very time-consuming but gave the students little added value. After the first series of eight articles, this top-five

assignment was ignored by most of the students, and it was finally abandoned by the instructors on the last set of eight theoretical articles.

To indicate the helpfulness of the website, the students were asked to give their opinion about the different workforms in relation to the learning goals (see Figs. 6, 7, and 8). For this, five-point scale questions in a questionnaire were used. In comparison with 1998, the 1999 website shows significantly higher appreciation scores for its contribution to knowledge acquisition (Mann-Whitney test, $Z = -7.16$, sign.level $= 0.001$) and insight improvement ($Z = -5.71$, sign.level $= 0.001$), and a slightly higher score for its contribution to the application of knowledge ($Z = -2.69$, sign.level $= 0.01$). The small-group sessions are clearly highly appreciated. Also the group discussions are perceived as important for learning purposes. In an interview regarding the 1999 course with a panel of students, the students indicated that the fact that not everybody reads every article creates an interdependency that has positive effects on discussion and collaboration. The production of summaries for each other was thought to be a highly relevant task, as these summaries are a good introduction for those group members who have not read the article. Access to other groups' work also allows students to compare their work with that of others. The score for item 4, Table 5, supports the conclusion that the opinion of the students with respect to the website has shifted from negative in 1998 to neutral in 1999.

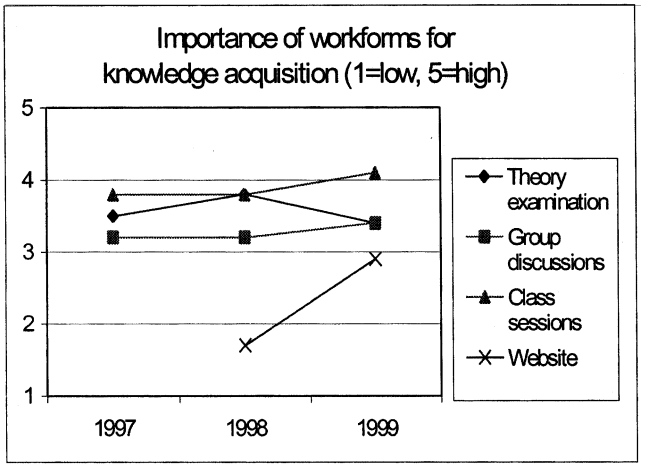

Fig. 6. Appreciation of the importance of the different workforms for the learning goal "knowledge acquisition" (1997: $n = 110$; 1998: $n = 83$; 1999: $n = 110$).

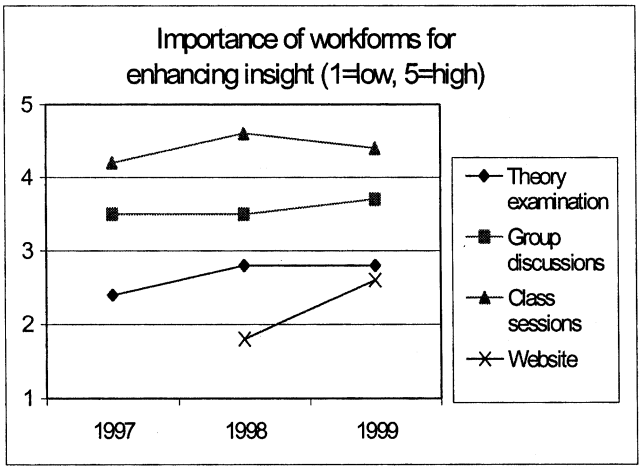

Fig. 7. Appreciation of the importance of the different workforms for the learning goal "enhancing insight" (1997: $n = 110$; 1998: $n = 83$; 1999: $n = 110$).

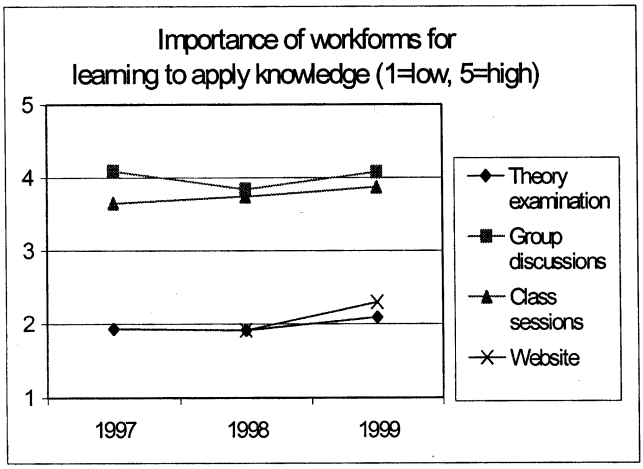

Fig. 8. Appreciation of the importance of the different workforms for the learning goal "learning to apply knowledge in problem solving" (1997: $n = 110$; 1998: $n = 83$; 1999: $n = 110$).

Question 4: Did Students Use the Group Archives?

When looking at the actual use of the group archives, we see that in 1998 only 5 out of 28 groups used the group archives, partly because the group archives

were not introduced directly at the start of the course. Some students indicated on the student questionnaire that they did not know what the group archive was. Other students who knew about the group archive but did not use it reported in the interview that they did not want to invest time in learning to use software from which they expected only limited benefits. Sharing files was mainly organized by using diskettes and e-mail messages with attachments. Via the student questionnaire, two out of three students reported using e-mail messages for the 1998 course.

In 1999 the group archives were available from the start of the course. The interface was simplified using just one directory which listed all files in alphabetical order. The group archives (Fig. 5) were used by all but one group, storing an average number of 20 files, compared with an average of only 2 files the year before (item 5, Table 4). However, analysis shows that, during the second half of the course, the number of groups still using the group archives dropped from 22 to 14, indicating that some groups abandoned using the archive part of the website altogether. The groups that did use the archive asked for some improvements, such as the possibility of making subdirectories. These groups had amassed a considerable number of files and some reported losing an overview because only one single directory was available. E-mail was again used by two out of three students in the context of the course. However, the rate of e-mail usage differed between the students using the group archives and those who did not. Only 54% of students using the archive used e-mail, while 83% of students reporting not to have used the group archives said they used e-mail. This difference is significant at the 0.005 level; Fisher exact test, Pearson $\chi^2 = 8.5$ (see Table 6).

This finding was checked by looking at the scores on these questions per group, only taking into account groups where at least three students had responded to the questions about the group archive and e-mail. In Table 7 the

Table 6. Comparison of Students Reporting to Have Used Group Archives and Students Confirming Use of E-mail for the 1999 Course.

Group archive & e-mail		Did your group use the group archive for your group work?		
		Yes	No	Total
Did you use e-mail for this course?	Yes	**33** (54%)	**30** (83%)	**63**(65%)
	No	**28** (46%)	**6** (17%)	**34** (35%)
	Total	**61**	**36**	**97**

Table 7. Use of E-mail and Group Archives by Groups in 1999.

		Did your group use the group archive for group work?	
		Mostly yes	Mostly no
Did you use E-mail for this course?	Mostly yes	**4**	**9**
	Mostly no	**7**	**0**

groups are characterized according to their profiles of using these two forms of telematic support, with clearly no groups discarding telematic support altogether. So it seems that all student groups made use of telematics tools to share information, showing a preference for either or both using e-mail and the group archive. Possible reasons for groups to prefer e-mail could be that e-mail allows the combination of exchanging files and communication at the same time. Also for the time being e-mail is a more familiar application to the user than group archives.

Question 5: Does the Website Improve Student Results?

The effect of use of the website on student results is difficult to measure. Instructors reported that it is very difficult to attribute outcomes to specific learning events. The course is a complex integration of different elements. The instructors considered the overall result as a strong combination of aspects. An

Table 8. Correlation Values for Website Activity Variables and Course Grades.

Pearson correlation values	Theory grade		Case-study grade	
	1998	1999	1998	1999
	$n = 28$	$n = 23$	$n = 27$	$n = 23$
1 Number of contributions (number of contributions in database)	−0.03 n.s.	−0.31 n.s.	−0.26 n.s.	−0.30 n.s.
2 Quality of contributions (percentage approved contributions)	−0.41 *	−0.55 **	−0.09 n.s.	−0.07 n.s.
3 Cross-group reading (number of website reading events)	−0.23 n.s.	0.01 n.s.	0.11 n.s.	0.04 n.s.

n.s. = not significant; * = significant at 0.05 level; ** = significant at 0.01 level.

analysis was carried out to check for correlations between the theory examination and case-study grades, and website-related activities (see Table 8). The calculations were performed at group level.

Groups using the website more frequently for reading the work of other groups did not score better in the grading of the case-study report. The only significant correlations are found between the quality of the contributions and the mean theory grade: −0.44 in 1998, versus + 0.55 in 1999. The negative correlation (−0.44) of 1998 indicates that some students who were good at theory did not perform well in the website activity, which was also theory-related. This could be because the website task was not good or the motivation of these students was low (see also 1998 website scores in Figs. 6 and 7). The student-panel interview confirmed that their motivation for the website task in 1998 was low. With the adjusted set-up for 1999, the percentage of approved contributions is now a positive predictor for the theory grade. Linear regression analysis gives the following relation (see also the scatterplot in Fig. 9):

Theory grade = 5.34 + 0.023 × Percentage approved contributions $R^2 = 0.30$

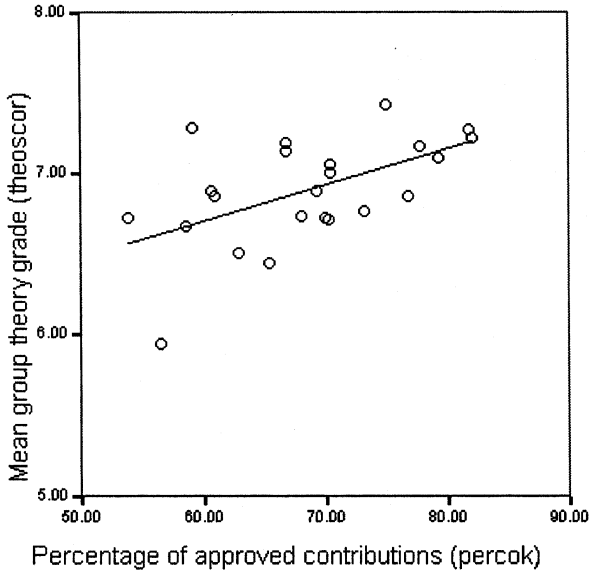

Fig. 9. Scatterplot of the means of the theory score of group members (vertical) versus the percentage of approved contributions that were submitted via the website of the 1999 course.

For example, group percentages of approved contributions of 60% and 80% predict mean theory grades for the group members of 6.72 and 7.18 respectively, on a 10-point scale. Additional correlation checking showed that there was no significant correlation between the theory grades and the case-study grades. In the instructor interview the instructors confirmed that transfer from reading theory to application of theory in a problem-solving setting is not taking place as much as they would like.

Question 6: Was the Website Easy to Use?

The website was easy to use, according to the students (item 2, Table 5). Keystroke analysis showed that in 1999 users needed 20–54% fewer keystrokes or mouse clicks for their website-related tasks, compared to 1998 (see Table 9 for the reduction of the steps needed for the basic user tasks associated with the use of the website).

Reductions in the number of required user steps was partly achieved by relating the user log-in at the start of a session to specific views of the contributions. By exploiting the knowledge about group membership and access rights, the student no longer had to specify or select items that are needed for the database queries. The simplified user interfaces also resulted in a reduction of mistaken submissions, from 9.1% in 1998 to 1.9% in 1999. Mistaken entries consisted mainly of submitted empty forms and forms that were sent in twice.

The instructor assessment task was made more efficient by automating the access-control mechanism. This reduced the instructor workload and shortened the learning curve to a minimum. Also, the automation eliminated errors in granting of access, which occurred in 2.4% of all cases in 1998.

Table 9. Improving Ergnomics as a Result of Analyzing Required Keystrokes and Mouse Clicks.

Basic user tasks	Number of steps		Reduction (%)
	1998	1999	1999 vs 1998
Submitting a contribution	9	5	44
Reading contributions of group members	10	5	50
Reading contributions of other groups	11	5	54
Uploading a file into the group archive	8	5	37
Downloading a file from the group archive	5	4	20
Assessing contributions (instructor task)	26	18	31

DISCUSSION

From our results, it appears that both versions of the Web application used in this study helped to stimulate the students to work more actively with the theoretical materials offered. Apart from reading the articles themselves, a majority of students in 1999 used the website to read summaries written both by students from their own group and also from other groups. Compared with the situation in 1997, the discipline of reading can now be monitored by the instructors to a larger extent. A paper-based solution that accomplishes the same result is difficult to imagine. The students are willing to work with the website tasks if they feel they benefit from this in terms of their assessment in the course.

The 1999 evaluation shows that the revised set-up of the Web-based "theory repository" was perceived by students as more helpful than the 1998 version. In 1999, substantial reading of the work of other groups took place. Although many factors have remained relatively stable over the years, a number of possible reasons for the differences in cross-group reading of contributions can be postulated:

- In 1998 the contributions consisted of sets of questions and answers. Summaries may be more helpful when students want to learn about an article without reading it.
- The pre-selection of the excellent articles in 1999 made this option more efficient for the students.
- Students have more control choosing, themselves, to read the work of others or not (1999), compared to being forced to read others' work and then rank it (1998).
- The improved user interface makes the use of the website more efficient.

The combination of changes in instructional design with an improved user interface makes it difficult to factor out the dominant cause of the improvement. However, based on discussions with students, we believe that the first explanation, a relevant and helpful task, dominates the students' appreciation. Web support can help organize these tasks in an efficient way. Although the Web support thus activates the learning behavior of the students, students appreciate most highly those learning settings in which they interact with their peer students and the instructors. However, we believe that these discussions are more fruitful when the students have been better introduced to the relevant theory.

A correlation was found between the students' Web-related activities and the theory examination results, but not between Web-related activities and the final case-study results. Transfer from the theory parts of the course to the case-study problem-solving tasks is thus not as straightforward as anticipated.

Group archives for storing files can be useful support for the groups. They are used by a majority of students if they can use them without investing much time in learning to use the tool. However, as this part of the website was introduced differently in the two years, it is hard to compare the two solutions for this part of the Web support. Some students prefer the use of e-mail over group archives for distributing resources.

Future development will focus on the opportunities to integrate student options for sharing of information, as well as instructor options for assessment and monitoring into the generic Web-learning environment.

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