A cross-case comparison of BSCW in different educational settings

Klaas Sikkel[a], Lisa Gommer[b], and Jan van der Veen[b]

[a] Faculty of Computer Science, University of Twente,
PO Box 217, 7500 AE Enschede, the Netherlands
sikkel@cs.utwente.nl

[b] DINKEL Institute, University of Twente
PO Box 217, 7500 AE Enschede, the Netherlands
{E.M.Gommer, J.T.vanderVeen}@dinkel.utwente.nl

Abstract. We evaluate the use of BSCW shared workspaces in higher education by a comparison of seven courses in which this environment was used. We identified a number of different functions for which the BSCW environment has been used.
Effectiveness for the given task appears to be a prime success factor for using ICT. But an effective tool may fail due to other factors like ease of use and organisational, social-cultural or technological obstacles. In some cases BSCW was adequate, but abandoned in favour of more efficient tools for performing the same task.
The particular strength of a shared workspace is providing a repository for objects of collaborative work. While other types of usage showed mixed results, it is this core functionality for which BSCW is most effective and quite efficient.

Keywords*:* shared workspaces, collaborative authoring, evaluation of ICT usage.

1 Introduction

In Education, like in any sector, Information and Communication Technology (ICT) grows ever more important. There is a number of ways in which the use of technology can improve the quality of teaching and learning, or create a learning environment that could not exist otherwise. Virtual classrooms are a blessing in sparsely populated areas. Part-time students can save valuable travelling time through distance learning. Student working groups benefit from good ICT support for group work. In addition, the future professional should get acquainted with the tools of the trade, and for most professions these include a fair bit of ICT.

It is not the case, however, that the use of technology has a positive effect on education *per se*. Using ICT has some cost in terms of learning to work with a system, maintenance, and occasional disruption due to system failure. It possibly decreases flexibility and quality of interaction. There should be gains that offset the costs, in order to make it worthwhile. The question, how to make *effective* use of ICT in education, is far from settled and merits further investigation. It is important to share the lessons learned, both positive and negative, so as to develop a common understanding of how we can use the new technology to our advantage.

We evaluate one particular technology – BSCW shared workspaces – that has been used for a number of different purposes in a range of different educational settings. In a shared workspace a group of users can store documents and exchange information. It is a very general tool, offering a novel infrastructure that can be used for a lot of different purposes. This makes it a particularly interesting case of how ICT can enhance educational facilities. Indeed it has been used for a variety of different functions, with varying success. In this article we review the use of BSCW in seven different cases.

Section 2 gives an overview of the technical functionality of the BSCW shared workspace and the educational functions that can be supported. After a description of the research method in Section 3 and an account of the seven cases in Section 4, an analysis based on a cross-case comparison is given in Section 5. Conclusions are summarized in Section 6.

2 Basic Support for Cooperative Work

The BSCW Shared Workspace system

A BSCW shared workspace is a virtual space in which members of the workspace can store documents, messages, etc. A workspace is accessed with a conventional Web browser, but access is granted only to registered members of the workspace. Inside, the workspace is organized as a conventional folder structure. A typical BSCW folder (from actual use in a course) is shown in Figure 1.

The central functionality of a workspace is to provide a document storage facility. Additional features include

- Basic version management. A document history can be maintained as a sequence of versions.

- Locking. To prevent unintended simultaneous editing, documents can be locked.

- Awareness information. Icons attached to documents and lists of recent events allow the user to get an overview of what has happened in the workspace. Also it is possible to receive notification of certain types of events by email.

A workspace can handle documents of all kinds (text, images, audio, etc; any standard or non-standard MIME type). Other objects that can be stored in a workspace include

- Notes, attached to documents or as separate

Figure 1: a typical shared workspace folder

entities. Notes can be replied to by other group members, providing a mechanism for structured discussions.

- Links to Web pages outside the workspace.

A complete description of its features can be found on the BSCW web site (http://bscw.gmd.de).

The BSCW was developed as a research prototype for an internet-based groupware system, first released in 1995 (Bentley et al., 1995). A completely restyled and restructured version was released in 1996 (Bentley et al., 1997). Later versions have added a number of features but the core functionality and user interface has not changed since then.

These days similar functionality is offered by commercial systems, like Xexox DocuShare (docushare.xerox.com) with a more professional look and feel – and with a different price tag. BSCW has acquired popularity among institutions for higher education because of its low cost (free for non-commercial institutions) and high accessibility. This makes it particularly suitable for experimenting with ICT.

Using shared workspaces

The functionality of any system can be described at different levels. The technical functionality outlined above tells what you can do with a system in terms of features offered by the system. The domain functionality describes the functions the system can be used for in the application domain, in this case the educational domain. The remainder of the paper addresses the latter kind of functions.

The following list is not exhaustive but shows for which functions the system was used in the seven cases:

a. **Archiving.** The shared workspace is used as a group archive.
   Example: a project group is working on a product and uses BSCW to store their drafts, documentation and work planning documents.

b. **Collaborative authoring.**
Example: A group paper is stored in a workspace accessible to all the group members and everyone can add their parts and revisions.
Locking and versioning are technical functions that support collaborative authoring.

c. **Discussion.**
Example: Every week, a statement is put into the workspace by the teacher and students react on the statement and on each other's contributions. Technically this is supported by the threaded discussion feature of BSCW.

d. **Reviewing.** Commenting on each other's work, assessment or peer review
Example 1: Students have to write an article on a certain topic and during the following week, they have to comment on the work of their peers. During the lessons, the articles and comments are used as a starting point for discussion.
Example 2: Students hand in their work into their personal workspace. The teacher gives feedback by adding commentary notes to the assignments.
Figure 1 in fact shows a folder with a draft paper, two reviews by peer groups, and a final version based on the reviews.

e. **Monitoring.** The teacher monitors the students' activities.
Example 1: during a project, the tutor of a project group has access to its workspace to see how work is progressing, how the different project members are contributing and how much activity there is in the group.
Example 2: the course instructor gets daily notification emails from the BSCW server listing all events in the students' workspaces. These are collected for subsequent statistical analysis.
The awareness facilities allow a rough overview at a glance of what happens in a workspace, for monitoring a particular group, as in Example 1. For an in-depth statistical analysis it is possible to mine the BSCW server logs, but this requires additional work. Most of the salient statistics can be derived from the notification emails, if so required.

f. **Communication.** Exchange of messages for work planning, feedback, etc.
Example 1: Students put their assignments in a workspace folder, and the teacher gives feedback by adding notes to the students' folders.
Example 2: Instead of using email, a project group uses BSCW to schedule meetings, distribute agendas and minutes, communicate about work progress, etc.
BSCW has a facility for meeting scheduling. Participants invited for a meeting receive email with a request to acknowledge or cancel their presence at the meeting.

g. **Using ICT.**
Example: In a teacher training course, students work with BSCW to experience how ICT can be used in education and to get ideas about using ICT in their own courses.

h. **Logistics.**
Example 1: In a course, students have to hand in assignments to different teachers. Assignments are placed in a central folder, so each teacher can select the assignment she has to assess.
Example 2: Student groups may choose among different assignments, but no two groups may choose the same one. The assignment goes to the group that was the first to claim it in the workspace.
The second example exploits the fact that all actions in a workspace are time-stamped.

i. **Course info.** BSCW is used to disseminate information on the course, exercises, etc.
Example: A shared workspace folder contains information about the tasks to be carried out. Thus the information can be adapted as necessary during the course.
This is not a function for which BSCW is needed; the same material could be put on a web page (or distributed on paper). Reasons to use BSCW could be that the instructor did not have easy access to a web server or that it is convenient to put this information and the students' contributions in the same environment.

j. **Access control.**
Because a workspace is password-protected it provides a simple way to put resources on the Web without making them accessible to the entire internet. Furthermore, access to documents and folders can be restricted to particular subgroups.
Example 1: Students make a portfolio, presenting their skills and experiences. They may not want to present this publicly on the internet.
Example 2: In a course where students have to hand in assignments, BSCW is used as an access mechanism. When a student has handed in his or her assignment, and it is graded by the teacher, the student gets access to the work of fellow students, by making him a member of a particular user group.
The last example involves some manual action of the course instructors. In one course (not in this survey) the BSCW environment has been extended to support this type of use (van der Veen et al., 2000)

3 The evaluation framework

For the evaluation of BSCW we review a number of case studies. The investigation is of a qualitative nature (although quantitative methods have been used in the evaluation of several cases). The purpose of this study is not to obtain statistically significant results, but to investigate possible reasons for success or failure. The case studies were selected because they cover a wide range of different educational activities. By analysing and comparing the different cases, our goal is to understand why the use of BSCW in education has been successful in some educational settings and rather unsuccessful in others.

The qualitative nature of this investigation has some implications for the generalization of the findings (Yin, 1994). Our findings could be validated by further

empirical research. Yet, in order to do such research, one should be able to make educated guess of what the indicators for success and failure are.

In 1999 an extensive evaluation of the use of BSCW at the University of Twente was carried out (Gommer, 1999), covering all educational settings in which the system had been used at this university in the past two years. In order to gather data for the case studies in this evaluation research, several methods were used. First of all, structured interviews were held with teachers and instructors. An interview scheme was used with questions about subjects like the amount of training needed, support, functionalities and appreciation of BSCW. In several of these courses, data were obtained from students and course participants by means of questionnaires. These questionnaires contained both open and multiple choice questions and dealt with subjects like frequency of use, learning curve, functionalities, support, appreciation and technical problems.

From the eleven cases described in the evaluation, four were selected for this study. Three of these took place at the University of Twente (UT), one was conducted by UT staff at the Noordelijke Hogeschool at Leeuwarden, a university of professional education*. These particular four cases were selected because they differed most from each other in the way in which BSCW was used, the type of users and the extent to which the system was used successfully. Two of these were rather successful, the two other ones are relative failures.

In addition we selected three cases from other institutes of higher education, to compensate for the specific setting of the University of Twente. The selection criterion we used to select the external cases, was the amount of detailed information we could find about these cases. We needed sufficient information about the educational setting, the target group, the extent to which BSCW was a success, and the interpretation of the case study in terms of our evaluation model.

4 Case studies

Because of space limitations we give very brief accounts of the cases.

Case 1: "Didactic Training"
Teacher training course, University of Twente, 1998/99 (Gommer 1999)

The university provide an intensive didactic training for new teaching staff. Course sessions are every two weeks; in between, groups of participants meet (live or virtual) to work on group assignments.

In order to let the new university teachers experience the use of ICT in education, several ICT-tools are used in this course; a website, email and BSCW. The course website

---

* Universities of Professional Education ("Hogescholen") in the Netherlands, like "Fachhochschulen" in Germany, are distinct from regular universities and offer a degree comparable to Bachelor.

was used to supply the participants with information about assignments and activities. Email was used for communication between participants and instructors.

BSCW was introduced to support group assignments. Also, every participant had a personal folder (portfolio) in BSCW where all course assignments and projects were stored. The instructors put their personal feedback to every course participant in this portfolio. The progress of the participants was monitored by the instructors in BSCW. During the first weeks, discussions about educational topics (e.g. about teaching strategies) were started in BSCW by the instructors. The first course day included a tutorial session on BSCW.

Intended use: *archiving, collaborative authoring, discussion, reviewing, monitoring, communication, using ICT*

BSCW was used by all participants except one who insisted on using email. BSCW was mainly used as a central place for handing in and storing assignments and reports. Discussions started, but quickly faded away. Also, most groups did not use BSCW for group assignments. The groups met face to face to divide tasks and exchanged files and communicated about work planning by email. Only the final products were put in BSCW for assessment and feedback from the instructors.

The instructors used BSCW for progress monitoring, to see how the course members were doing and if everyone was still on schedule. They complained however, about this task being difficult because of the folder-structure.

All group members experienced the use of groupware and some indicated getting ideas for implementing groupware into their own courses.

Realized use: *archiving, reviewing, monitoring, using ICT*
not realized: *collaborative authoring, discussion, communication*

Case 2: "Design Project"
Multidisciplinary design project, University of Twente, 1998/99 (Gommer 1999)

Teams of 5-8 students from different faculties work on problems submitted by companies or institutions outside the university. Students spend 240 hours on this project. Teams are coached by a teacher but otherwise operate autonomously.
BSCW was offered as a facility but its use was not required. Support was limited to a demo at the start session and a 4-page overview of the most important functionality.
Evaluation was done by means of a questionnaire about BSCW usage and satisfaction, included in the course evaluation form.

Intended use: *archiving, collaborative authoring, communication*

The evaluation results showed that most project groups used BSCW for archiving and cooperation. Some

groups used their own solutions, for example an FTP-server.

Communication was done in BSCW by half the project groups. The other groups preferred email.

Realized use: *archiving, collaborative authoring*
partially realized: *communication*

Case 3: "CSCW course"
Course on computer-supported cooperative work, University of Twente, 1998/99 (Gommer 1999)

A substantial part of the course consists of exploring a particular sub-field of CSCW in groups of 3-4 students. Each group had to submit a preliminary report, to be reviewed by two peer groups, before writing a final report.

A shared workspace had to be used for exchanging reports and reviews. Whether it was used for collaborative authoring and archiving was up to the groups.

BSCW was used as a logistic tool to distribute themes. Every group should pick a different theme from the list. If two groups wanted the same theme, it was assigned to the group which first put a claim it in the workspace.

Intended use: *archiving, collaborative authoring, reviewing, using ICT, logistics*

Use of BSCW for peer review and logistics was successful. Also, because groupware was the subject matter of the course, finding out the advantages and the disadvantaged of the system was an intended and realized aim.

Only a few groups used the system for collaborative authoring, however; most groups uploaded their work when a paper was due. This is not surprising, as most groups saw each other regularly face to face.

Realized use: *archiving, reviewing, using ICT, logistics*
partially realized: collaborative authoring

Case 4: "ICT course"
ICT course for teachers, Noordelijke Hogeschool Leeuwarden, 1998/99 (Gommer 1999)

The course was given on-site at a university of professional education in Leeuwarden by instructors from the educational centre of the University of Twente. In this course, teachers worked together in groups on a design for implementing ICT in one of their courses. In three course sessions, lasting a whole day, participants listened to lectures about ICT in education and worked on their products in groups, supported by two instructors. In between course days, the course participants were supposed to work on their products too, with the possibility to receive technical and educational support from the instructors through email or BSCW.

During the course, a course website and BSCW were used to let the teachers experience the use of ICT in education themselves. The goal was to let the groups work together in BSCW on their product and to give groups access to the workspaces of the other groups so they could learn from each other, share ideas and comment on each others' products.

Intended use: *collaborative authoring, reviewing, using ICT*

By most groups, BSCW was rarely used after the training session. The groups chose to carry their products around on diskettes and hand in assignments to the instructors on paper or by email. One or two groups decided to put their products in BSCW, but since other groups didn't, there weren't many interesting things for them to see in the other workspaces. Because most teachers only worked with BSCW at the training session, they did not really experience the benefits and drawbacks of working with a groupware tool.

Partially realized: *using ICT*
not realized: *collaborative authoring, reviewing*

Case 5: "Law and Informatics"
University of Amsterdam, 1997 (Groothuismink, 1998)

Law students used BSCW for group assignments. Each group placed both product and process related information in their group workspace. Instructors commented on working plans and deliverables. A course folder contained course information and final deliverables of groups, so that these were accessible to other groups. Each student thus had access to two folders: one group archive and one course archive. Communication was also planned to take place via the workspaces.

Intended use: *archiving, collaborative authoring, reviewing, monitoring, communication, course info*

Students appreciated the flexibility of the website and the access to course related information. The instructors added that electronic communications have lowered the hierarchical distance between staff and students. The workload of the staff however increased due to the answering of email messages. Technical problems reported relate to laborious user administration and poor server performance due to the fact that the server was also supporting other services at the same time. Students reported that they need quite some time to learn the tool. Also the editing of documents and the successive uploading was experienced as difficult. For communication email was preferred.

Realized use: *archiving, collaborative authoring, reviewing, course info.*
partially realized: *monitoring*
not realized: *communication*

Case 6: "Pupil Counselling"
Training course for teachers, Hogeschool van Utrecht (Koenraad, 1999)

A group of 25 students was involved in a course module on "Pupil Counselling & Remedial Teaching". The module consists of a theoretical part and a practical period, in which groups of three students worked on assignments. Their deliverables were to be presented to their fellow students and instructors via BSCW. The students were expected to comment on the methods, results and presentation of other groups.

Sub-directories were prepared, some of these being used to provide course materials. A discussion directory should serve as a platform for online communication.

Intended use: *archiving, collaborative authoring, discussion, reviewing, course info.*

The students were satisfied about their own sub-group way of working and product. Students reported that form most of the task interaction with group members was not much needed, interaction with other students even less. The planned peer commenting did not work well. Some groups ignored this task, possibly because of not being aware that a certain deliverable was waiting for a review. Most students, all with no prior groupware experience, report the BSCW user interface to be unfriendly. Those groups favouring BSCW did use the system extensively in combination with email for more prompting communication purposes.

Realized use: *archiving, collaborative authoring, course info*
partially realized*: discussion*
not realized: *reviewing*

Case 7: "Software Engineering"
University of Durham (UK), 1997/98, 1998/99
(Drummond and Boldyreff, 1999, 2000)

The Computer Science staff implemented an infrastructure for team work, called SEGWorld, which is essentially a BSCW server with a few enhancements. The course has been given from 1997 onwards, evaluations for 1997/98 and 1998/99 are available (Drummond and Boldyreff, 1999, 2000). The system serves as an infrastructure for keeping group work organized. At the various deliverable deadlines, the assignments are automatically copied form the groups' workspaces. So it serves both to share documents in the group and to hand in the results. The student groups also review each other's deliverables at various point during the course.

Intended use: *archiving, collaborative authoring, reviewing, communication, using ICT, course info, access control*

In the first course there were some technical problems with the system, and the server was rather slow, which impeded the use of the system. Also the initial training was not felt to be adequate. The system was used for storing the results (this was obligatory). In a questionnaire, 50 % of the students said the system helped to organize the work , 65 % indicated that the workspace structure was useful. Only 2 % said the system resulted in better communication with the tutor and the group. (This was not stated as an aim for the course). In the second year, these figures were 68 %, 82 % and 12 %, respectively.

A daily log summary of the workspace was generated using BSCW's "workspace report" feature (notification by email of events in the workspace), primarily with the purpose of gathering statistical data. This yielded another – unanticipated – benefit: it provided the tutors with some insights into the contributions of the individual students with the group and more generally gave a means of

assessing a group's progress.

Realized use: *archiving, reviewing, using ICT, course info, access control*
unanticipated use: *monitoring*
partially realized: *collaborative authoring, communication*

5 Cross-case comparison

Table 1, in which the results are summarized, shows that some functions are used more than others. It should be noted that no statistical significance can be attributed to that, as the sample has not been selected to be representative in this respect. What is relevant here, is to uncover possible reasons why certain functions are successful in some case and fail in other cases.

Collis et al. (1999, 2000) give a model for predicting whether an ICT application in an educational setting will be successful. This so-called 4E model comprises 4 factors:

- Effectiveness
- Ease of use, which includes learnability and a friendly user interface, but also efficiency for a particular task
- Engagement: person feelings related to the use of ICT
- Environment: organisational, social-cultural and technological factors.

Each factor has a certain value, and the 4E model states that the ICT application will be used if the sum value exceeds a certain threshold.

If using BSCW for some function is (un)successful in all cases, it is most probably (not) effective. However, if the function was successful in some cases and a failure in others, the 4E model may give an explanation of why this happened. We will discuss each of the identified functions.

Archiving is used in all cases but one, and is always reported to be a success (although not always a 100 % success; occasionally groups didn't use it). Archiving is the core function offered by the BSCW system, so it can be expected to be particularly suitable for that purpose, and it does not come as a surprise that this function is generally accepted.

Collaborative authoring was intended to be used in all cases, with rather different results. The following reasons emerged for not using BSCW for collaborative authoring. In the didactic training and the CSCW course, the students regularly met face to face, and saw no reason to put collaborative work into a workspace. In the Software Engineering course, the system was rather slow and the students, all having access to the same local network, used a UNIX directory because of its better performance.

In the ICT course the breakdown was caused by other factors. The participants were motivated to learn about ICT, but not very experienced. The participants were

Table 1. cross comparison of cases

	1 Didactic training	2 Design project	3 CSCW course	4 ICT course	5 Law & Inform-atics	6 Pupil couns-elling	7 Softw. Engin-eering	Success / failure:		
								+	+/–	–
a. Archiving	+	+	+		+	+	+	6		
b. Coll. authoring	–	+	+/–	–	+	+	+/–	3	2	2
c. Discussion	–					+/–			1	1
d. Reviewing	+		+	–	+	–	+	4		2
e. Monitoring	+				+/–		+	2	1	
f. Communication	–	+/–			–		+/–		2	2
g. Using ICT	+		+	+/–			+	3	1	
h. Logistics			+					1		
i. Course info					+	+	+	3		
j: Access control							+	1		

teachers who did this on top of their (considerable) normal work load. So when it came to doing homework, it was too tempting to revert to proven methods known to work.

Note that the use of BSCW as a tool for collaborative authoring was accepted more naturally in an environment where ICT is not ubiquitous but specially provided for this purpose (cases 5 and 6). The relative effectiveness of a tool is enhanced by *lack of* alternatives for the same function.

Discussion was not really successful anywhere. Both cases in which it was intended to be used suffered from the same flaws: participating in a discussion was not a learning aim of the course and, moreover, there were enough possibilities for live interaction for those who wanted to engage in further discussion.

We suspect that online discussion facilities were offered simply because the technology is available, and teachers expected students to be eager to use it. Anybody considering using this feature should be very clear about its purpose, as well as the effectiveness and the efficiency for this purpose.

Reviewing worked well in four out of six cases. Failures occurred the ICT course (generally unsuccessful), in which looking at other work of other groups failed because there was hardly anything in the workspace and case 6, pupil counselling, where participants did not do it, perhaps because they did not notice there was material to be reviewed. Success seems dependent on the course set-up and the overall success of using BSCW in a course.

Monitoring shows varying results. Monitoring by browsing through the workspaces is tedious. A basis for more systematic monitoring is provided by the daily notification emails provided by the server, as the Software Engineering course successfully demonstrated. If monitoring is intended, additional automatic processing of raw data is to be implemented locally.

Communication was nowhere really successful, apparently because there are more effective ways to communicate, such as email. Noteworthy in the Law & Informatics course is that the use of a workspace resulted in *more* communication between students and teachers and led to an increase in the use of email. BSCW was not used as a communication medium, but the use of BSCW lowered the threshold to communicate with teachers through email. A form of communication where the lack of obtrusiveness provided by BSCW is an advantage is handing in assignments. These need no immediate response, can be collected from the workspace after the deadline, and do not clutter up the instructors' private mailboxes.

Collaboration involves communication on two levels: exchange of the objects of collaborative work and discussion about these objects (Robinson, 1991). Hence it seems reasonable to use a workspace as the medium for storing objects of collaboration, while email is used for the meta-level communication. In a normal computer-based working environment, both media are present.

Course information disseminated through a shared workspace does work, in the sense that people will pick it up. Interestingly, in Law & Informatics, it was decided to revert to paper the next year because everybody printed it. We conclude that is should not replace the course manual but only be used for information of a more volatile nature.

Using ICT was mentioned as an objective four times, and reported to be successful three times. The table confirms previous findings (Sikkel and van Veen, 1998) that the objective to use ICT is successful only if it is used in a way that is effective for the course objectives (excluding using ICT as a goal in itself). A very engaged user may thoroughly explore the system, but for group work this cannot compensate lack of effectiveness, as the critical mass for success – which is full participation with a working group – is never reached (Dix, 1997). But if the ICT is effective, and there are no serious breakdowns, it will be naturally accepted.

6 Conclusion

The focus of this study is on effectiveness and efficiency of BSCW as a tool for the different functions for which it has been applied. The 4E model of Collis et al. shows that other factors are equally important for the success of an ICT application in an educational setting. If the technological, organisational and social environment and personal engagement of participants obstruct a proper functioning of the tool, it is likely to fail.

Having said this, it must be added that effectiveness is a necessary condition for success. If a tool is not effective, there is no reason to use it. A second source of effectiveness failure is that the chosen tool is effective for the particular activity, but the planned activity is not effective for reaching the overall objectives of a course.

Efficiency is important in a similar way. If there is a more efficient way to fulfill a task, students are naturally – and rightly – inclined to use that.

The particular strength of a shared workspace, not surprisingly, is what can be considered as it's core functionality: providing a repository for objects of collaborative work. Using a shared workspace as an archive was successful in all cases.

The BSCW system, originally designed as a *basic* shared workspace system, has a range of features that support a variety of educational functions. These have been tried in different settings, with varying success, as discussed above. One of the reasons could have been that for a given course a *single* system (BSCW) was chosen for ICT support, and it has been tried to exploit this particular system for multiple purposes.

In the future we expect that learning takes place in an integrated, open ICT environment in which different kinds of tools are available for different purposes and users can switch between tools as appropriate. We could observe in several of the case studies that non-use of BSCW did not mean that a particular task was not performed but, on the contrary, a more efficient ICT solution for the same function was available. Shared workspaces have proven to be highly useful, but it seems advisable that their purpose be limited to what they were originally designed for.

References

Bentley, R., T. Horstmann, K. Sikkel and J. Trevor (1995). Supporting collaborative information sharing with the World-Wide Web: The BSCW Shared Workspace system. *Proc. 4th international WWW conference*, Boston, Mass., pp. 63-73

Bentley, R., W. Appelt, U. Busbach, E. Hinrichs, D. Kerr, K. Sikkel, J. Trevor and G. Woetzel (1997). Basic support for cooperative work on the World Wide Web.*International Journal of Human-Computer Studies* Vol. 46, pp. 827-846.

Collis, B. and N. Pals (1999). A Model for Predicting an Individual's Use of a Telematics Application for a Learning-Related Purpose. *International Journal of Educational Telecommunications*, Vol. 6, pp. 63–103.

Collis, B., O. Peters, and N. Pals (2000). A Model for Predicting the Educational Use of Information and Communication Technologies. Submitted to Journal of Instructional Science.

Dix, A. (1997). Challenges and Perspectives for Cooperative Work on the Web: An Analytical Approach. *Computer Supported Cooperative Work: The Journal of Collaborative Computing*, Vol. 6, pp. 135–156.

Drummond, S. and C. Boldyreff (1999). SEGWorld: A WWW-based Inforastructure to Support the Development of Shared Software Engineering Artifacts. Workshop on Web-Based Infrastructures and Coordination Architectures for Collaborative Enterprises, IEEE 8th Int. Workshop on Enabling Technologies: Infrastructure for Collaborative Enterprises (WET-ICE'99).

Drummond, S. and C. Boldyreff (2000). The Development and Trial of SEGWorld: A Virtual Environment for Software Engineering Student Group Work" (1999) *IEEE 13th Conference on Software Engineering Education and Training (CSEE&T 2000)* Austin, Texas, USA, pp. 87 -97

Gommer, E.M. (1999). Eindrapport Evaluatie BSCW. OC-Doc 99-10, Onderwijskundig Centrum, Universiteit Twente.

Groothuismink, J. (1998). Het gebruik van groupware door samenwerkende studenten. In: *Internet & Onderwijs, 9 voorbeelden van Internettoepassingen in het wetenschappelijk onderwijs*, Universiteit van Amsterdam

Koenraad, A.L.M. (1999). Groupware ter ondersteuning van samenwerken en samenwerkend leren. Proceedings Nederlands Informatica Onderwijs Congres (NIOC'99), Enschede, Netherlands.

Robinson, M. (1991). Double-Level Languages and Co-operative Working. *AI and Society*, Vol. 5, pp. 34–60.

Sikkel, K. and J. van der Veen (1998). Using Shared Workspaces in Higher Education. Unpublished draft, Faculty of Computer Science, University of Twente, Enschede, the Netherlands.

van der Veen, J.T., V. Jones, and B.A. Collis (2000). 'Theory Repositories' via the Web for Problem-Based Learning. *Interactive Learning Environments* 8(3), pp. 257–277

Yin, R.K. (1994). *Case Study Research: Design and Methods*. Second edition. Sage publications, London.