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Expanding Technological Frames Towards Mediated Collaboration

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Groupware Adoption in Virtual Learning Teams

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Abstract: This paper provides an in-depth analysis of the technological and social factors that led to the successful adoption of groupware by a virtual team in a educational setting. Drawing on a theoretical framework based on the concept of technological frames, we conducted an action research study to analyse the chronological sequence of events in groupware adoption. We argue that groupware adoption can be conceptualised as a three-step process of expanding and aligning individual technological frames towards groupware. The first step comprises activities that bring knowledge of new technological opportunities to the participants. The second step involves facilitating the participants to articulate and evaluate their work practices and their use of tech-

nology. The third and final step deals with the participants' commitment to, and practical enactment of, groupware technology. The alignment of individual technological frames requires the articulation and re-evaluation of experience with collaborative practice and with the use of technology. One of the key findings is that this activity cannot take place at the outset of groupware adoption.

Keywords: Technological frames, Virtual Team, Groupware adoption, Learning, Action research.

1 Introduction

When adults return to universities for vocational education, they often find that the other students are based in different physical locations. This complicates collaborative learning. Groupware technology can, however, promote collaboration in such situations and is especially relevant for education programmes that involve project work by geographically dispersed groups (Dirckinck-Holmfeld and Sørensen 1999; Cheesman and Heilesen 1999). Current research on teamwork in geographically distributed situations, referred to as virtual teams, have investigated important aspects such as trust, mutual knowledge, culture, media-stickiness, and time (Cramton 2001; Maznevski and Chudoba 2000; Huysman et al. 2003; Jarvenpaa et al. 1998; Massey et al. 2001). In addition, researchers generally agree that technology plays an important role for the success of virtual teams (e.g., O'Connor et al. 1993; Hollingshead et al. 1993). In particular, research on the adoption of groupware technology shows that appropriate guidance on the adoption processes is crucial to achieve continuing use of groupware (Karsten 1999; Orlikowski 1992; Grudin 1994). Some research (e.g., Majchrazak et al. 2000) has addressed the actual adoption process of the technology by virtual teams, but few projects have been undertaken in this area to date.

The purpose of this paper is to complement this research by presenting the results of an action research project that guided the adoption of groupware by a virtual team of adult students in a part-time vocational education programme. It draws on Orlikowski and Gash's (1994) concept of the technological frame. We investigate changes in the technological frames of key actors during two cycles of the groupware adoption process. Technological frames comprise peoples' interpretations of a particular technology related to its nature, strategies and use. Because the functionality embedded in specific applications influences technological frames, it is important to investigate

technological factors. In addition, frames are affected by the engagement of people in social settings. It is therefore important that we also investigate the social factors that influence technological frames. Thus, our research question is: What technological and social factors influence the changes in virtual team members' technological frames towards adopting groupware?

To answer this question, we analyse a series of events that aligned practice and technology in a groupware adoption process. Specifically, we analyse how students change, expand and align their shared technological frames. By proposing that groupware adoption can be conceptualised as the expansion and alignment of technological frames, we argue that groupware adoption is a three-step process. The first step provides knowledge of new technological opportunities to the participants. The second step involves guidance so that they can articulate and re-evaluate their concrete work practices and technology use. The third step addresses the participants' commitment to groupware and their practical usage of a system. We also identify technological and social factors that influence successful groupware adoption.

This paper is structured as follows. Following this introduction, section 2 presents related research on groupware adoption. The theoretical framework of technological frames is then presented in section 3, followed in section 4 by descriptions of the empirical case study and the groupware technology. Section 5 introduces the action research approach, including descriptions of the data sources and how the data was analysed. Section 6 provides an empirical analysis, related to the theoretical framework of technological frames. This is followed in section 7 by a discussion of the technological and social factors that influenced the expansion of technological frames in the case study. Section 8 examines the implications for research and practice, concluding with a proposal for a three-step model of technological frame expansion.

2   Related Work: Groupware Adoption

To understand the adoption of complex technologies such as groupware we need to understand the realities of introducing technology at group level in specific organisational settings (Gallivan 2001). Groupware adoption is here viewed as a set of ongoing processes that align practice and technology so that they complement each other (Majchrazak et al. 2000). Majchrazak et al. (2000) argue that virtual teams may initially experience misalignment among pre-existing group practices and technology. In their study, the team first tried to resolve this misalignment by modifying the group practices while leaving the technology unchanged. However, the team experienced a series of events

that caused them to re-evaluate this approach. They made further modifications to   both the group practices and the technology structures. In the end these took on forms that were different from the pre-existing and the initial ones (Majchrazak et al. 2000). Groupware demands more effort and commitment from the people adopting the system than single-user systems (Grudin 1994). However, we still lack an in-depth understanding of which kinds of activities and factors actually foster the essential commitment of team members. Research on the organisational issues related to groupware adoption is therefore required to improve the adoption processes. Moreover, it has been found that successful groupware adoption depends on how well the technology is embedded in the local context, including local work practices. Adjustments to the technology thus play a key role in groupware adoption (Karsten 1999).

Users' capabilities to engage in successful groupware adoption are found to depend upon whether the users have a common ground and are ready to appropriate collaborative technologies (Olson and Olson 2000). This suggests that successful adoption depends on the users and their abilities to meet new challenges. Additionally, research in large organisations has found that the ability of users to communicate and to transform technology across different social worlds drives groupware adoption (Mark and Poltrock 2003). We do not yet know the factors that support the readiness of users for collaborative technologies. Nor do we know the factors that support users in the transformation of technology across social worlds. However, it has been suggested that users' capabilities to adopt groupware increase when they are given a clear understanding at the beginning of the adoption process of how the technological features are used in mature installations. Making sure that problems experienced early on are dealt with quickly prevents premature rejection (Grudin 1994). The initial stage of adoption is especially important, as actions taken immediately after the initial introduction and installation have been found to determine the path of technology use in the long run, while unproductive behavioural patterns concerning technology have been found difficult to change (Tyre and Orlikowski 1994; Huysman et al. 2003).

In summary, researchers generally agree that groupware adoption processes are influenced by both technological and social factors. Nevertheless we still need to identify these factors. In this paper we extend and supplement the current research by investigating and identifying technological and social factors that support groupware use. Thus we seek to improve the basic conditions for collaboration among geographically dispersed participants.

3 Theoretical Framework: Technological Frames

To understand users' capabilities and perspectives with respect to technology we apply the concept of the technological frame. People's frames of reference, or mental models about their work and technology, influence groupware adoption greatly (Orlikowski 1992). A mental model comprises the individual frame of reference, as in how participants view their work, the organisation and the technology. Orlikowski (1992) finds that groupware adoption is most likely to fail in the absence of mental models that appreciate its collaborative nature. Orlikowski further suggests that prospective users must have an appropriate understanding of the technology and their technological frames should reflect a perception of groupware as a collective rather than a personal tool (Orlikowski 1992, p. 386). All actions of individuals, including groupware adoption, are socially oriented and take place within a predefined social context (Lyytinen and Ngwenyama 1992). The social context of a team in, for example, education is a conglomeration of pieces that people bring from various social contexts in which they exist simultaneously, such as family and work contexts. How people perceive technology depends upon the particular social context in which the technology should be applied. The social context provides a repository of rules and resources that enable participants to make sense of each other's actions, including the use of technology. These allow them to interpret collective activities while adjusting their own work accordingly (Ngwenyama and Klein 1994). The members of a social group have individual interpretations, but they also possess a set of common core beliefs. Shared frames of reference in relation to technology within a specific social group comprise similar assumptions, knowledge and expectations on the role and nature of the technology. This includes specific conditions and consequences in a particular shared social context. Technological frames comprise the individuals' perceptions of technology. Shared technological frames emerge from an alignment process that results in a congruence of the individual technological frames on key elements and categories (Orlikowski and Gash 1994). Congruence means that structure and content are related, but not identical. Groupware adoption involves an alignment of the individuals' technology frames to create congruence, while expanding the shared frame to include new technological opportunities. Congruence is in this way similar to the concept of ecology, as suggested by Star and Ruhleder (1996) with reference to the delicate balance (or lack of balance) between language and practice. Groupware adoption requires a balance between the way that participants

P. Bjørn, A. Scupola & B. Fitzgerald • 33

perceive and articulate their technology-mediated collaborative practice and their practical implementation of collaboration and technology use.

The adoption of groupware is a process that aligns technology with work practice and results in a new or transformed practice (Berg 1998). Transforming practice should be guided by in-depth understandings of actual situated practices, rather than on plans describing practices because situated practices are influenced by but not equal to plans (Suchman 1983; Suchman 1987). Further, Robinson (1991) gives evidence that the provision of new computer-supported opportunities and capabilities is likely to be appreciated by the users. Prior to adoption, however, it is difficult, if not impossible, to identify the new capabilities that groupware will provide. Technology transforms practice in unanticipated ways, sometimes resulting in unintended social effects (Berg 1998). When a group appropriates a complex technology, the extent to which it is used can be much wider than it was designed to support (DeSanctis and Pool 1994; Kiesler 1986). The criteria for successful groupware adoption is thus that both technology and practice transform each other so that participants not only have the possibility of sharing and archiving documents in a common repository, but also that participants actively construct shared meanings of the shared objects and folder-structures through negotiations to be able to interpret the shared information items. Groupware should become a common information space (Hertzum 1999).

Orlikowski and Gash (1994) suggest three domains that characterise the technological frames of participants: the nature of technology, technology strategies and technology-in-use. The nature of technology domain comprises peoples' understanding of the capabilities and functions of the technology. Technology strategies comprise peoples' understanding of the motivation behind the decision to adopt it. Finally technology-in-use comprises peoples' understanding of how to use the technology on a day-to-day basis and the consequences associated with such use (Orlikowski and Gash 1994, p. 183).

Since frames of reference are individually held, they form schemes constructed upon the individuals' existence in various social contexts such as education, family and work. This means that factors outside the social context of education influence the expansion of individually held technological frames. In this paper, however, we focus on factors that influence the expansion of technological frames in relation to collaborative work in education. While we acknowledge the influence of factors from other social contexts on the adoption of groupware, we are emphasising factors that are directly located within the social context of education. We do not claim to have identified the complete set of factors that influence technological frame expansion, but we argue that we have identified a number of important factors that influence the expansion of technological frames in the social context of education.

In this paper we propose a conceptualisation of groupware adoption as the expansion and alignment of individual technological frames to include groupware. This concept provides for all three of the domains suggested by Orlikowski and Gash (1994). Expanding and aligning participants' shared knowledge of new technological opportunities includes gaining an understanding of the functionality of groupware. This takes the nature of technology domain into consideration. The functionality should be connected to the usefulness and motivation for adopting groupware in the specific setting. This takes account of the technology strategies domain. Furthermore, the participants should develop an understanding of the consequences of groupware use, combined with an ability to articulate unanticipated consequences. This gives attention to the technology-in-use domain. We can thus examine the technological frames of key actors related to the three domains. The sets of actors in the empirical study presented by this paper are teachers, students and the action researcher. We include the action researcher as a key actor, because this individual's technological frames influenced the groupware adoption process and the technological frame expansion of other participants.

The table below shows the theoretical framework that is used to analyse the empirical observations in this paper. It charts the three sets of actors in the groupware adoption process (teachers, students and the action researcher) against the technological frames related to the three domains (nature of technology, technological strategies and technology-in-use). We use this model to represent different stages of technological frame expansion during the case study.

	Teachers	Students	Action researcher
Nature of technology	What functionality and capabilities are embedded in the technology?	What functionality and capabilities are embedded in the technology?	What functionality and capabilities are embedded in the technology?
Technology strategies	What are the reasons and motivation for using groupware?	What are the reasons and motivation for using groupware?	What are the reasons and motivation for using groupware?
Technology-in-use	How should groupware be used in practice and by whom?	How should groupware be used in practice and by whom?	How should groupware be used in practice and by whom?

Table 1: Technological frames of key actors

P. Bjørn, A. Scupola & B. Fitzgerald • 35

4 The Empirical Research

4.1 Case Study Setting

The empirical investigation was conducted in a part-time master's degree programme (the Master of Adult Education at Roskilde University in Denmark), where groupware adoption by a virtual learning team was closely studied. The master program is a three-year, part-time university education for people who are active in the labour market. Students need to hold a bachelor's degree and to have at least two years of job experience to be accepted. Because it is a part-time programme, each semester is stretched over a whole year from September to June. Students are required to attend five weekend seminars on campus in September, November, January, March and April. Over 50% of the programme is based on problem-oriented project work (Dirckinck-Holmfeld 2002; Olsen and Pedersen 2005). Students are given a research question to investigate. They locate relevant literature, conduct empirical work and finally they co-author a project report.

The master's degree programme has a long tradition in vocational teaching for adults, but has no tradition in technology use for teaching or for collaboration among the students. In 2001, however, the teachers decided that they would like to employ technology in the new millennium, especially to support collaboration among the students in the intervals between the campus seminars. The teachers had no particular ideas which kind of technology to use, by whom or for what purpose.

The project team investigated here consisted of three students in their mid-thirties: Emma, Thomas and Lisa. All were in full-time employment and their study times were restricted to weekends and evenings. The three lived far apart and had few opportunities to meet face-to-face, apart from the five campus seminars. Because the team members had different working hours, most of their collaboration was asynchronous. Initially all three members of this group had email and phone experience, but no knowledge about groupware. This research was conducted during their final year in the master's programme.

The following table summarises the technological frames of the key actors at the initial stage of the action research project.

	Teachers	*Students*	*Action researcher*
Nature of technology	Had not really considered the nature of the technology.	Had experience of group work supported by email and phone, but no knowledge of groupware technology.	Groupware that supports collaboration in project groups in education needs functions such as coordination, shared archive, version control and negotiations.
Technology strategies	Other master's degree programmes have successfully employed technology. Technology could support students in collaboration between campus seminars.	Experienced communication and coordination difficulties in earlier projects. Groupware might resolve some of these issues.	Geographically distributed groups have difficulties collaborating. Groupware can provide opportunities for collaboration, reducing time for coordination, while increasing time for learning and negotiation.
Technology-in-use	Not really an issue. Teachers see themselves providing the technology. Then it is up to the students to employ it for their own benefit.	No idea.	The group should be assisted to negotiate common working procedures for groupware, including how, why and when to use it in specific situations related to their project.

Table 2: Initial Technological Frames of Key Actors

4.2 Groupware Technology

The groupware application used in this investigation was Basic Support for Cooperative Work (BSCW, further details at bscw.gmd.de), one of the most well known CSCW (Computer-Supported Cooperative Work) systems in the academic world (Bentley et al. 1997).

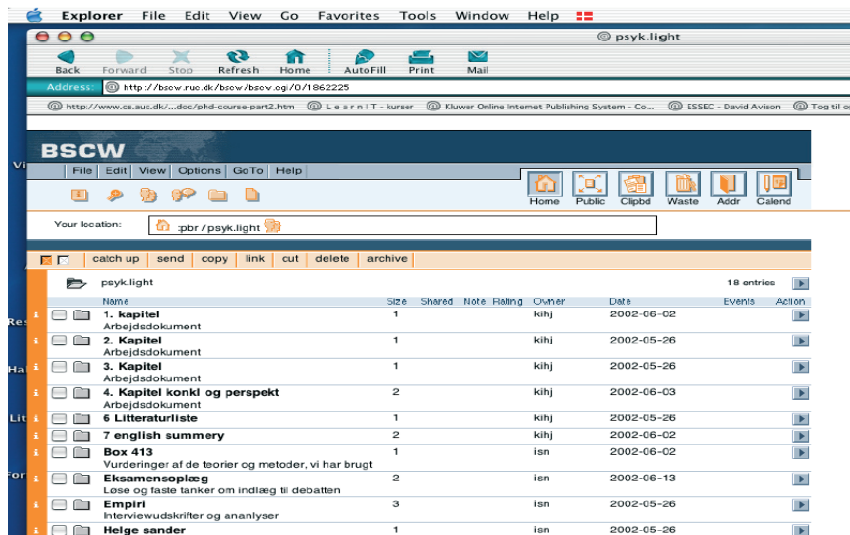P. Bjørn, A. Scupola & B. Fitzgerald • 37

Figure 1. Screen Shot of the Folder Structure at BSCW

The BSCW system is a web-based CSCW system, which supports file management, asynchronous and synchronous dialogues, the management of URLs and calendar functions. The BSCW system also supports different awareness functions, such as monitoring which documents, folders and notes are new, read, revised or moved. Automatic email notifications can be generated when specified events occur within the system. The BSCW's broad functionality and versatility allow users to adjust the conceptual structures, making it a strong tool for collaboration and coordination.

The group in this investigation accessed BSCW through stationary computers. These were located either in their homes, where they accessed the system over dial-up connections, or on campus, where broadband connections were provided.

5   The Action Research Approach

Research on the adoption and use of groupware in experimental settings has produced confusing and inconsistent results, because it is impossible to simulate real-life collaboration (Davison et al. 1998). Instead, Davison et al. (1998) propose using action research to fully capture the complexity of groupware use and collaboration. With this approach it becomes possible for the

researcher to become actively engaged in the practical adoption process. The researcher can intervene and positively influence the process, providing theoretical reflections that are grounded in planned activities. This increases of chances of identifying relevant new issues for groupware adoption.

The use of action research is well established in the information systems community (e.g., Mathiassen 1998, 2002; Avison et al. 1999; Vidgen and Braa 1997; Braa and Vidgen 2000; Donnellan 2003), where it combines theory and practice through change and reflection in a problematic real-life situation. Action research involves iterative cycles of activities: identifying problems, planning interventions, executing the actions, observing the outcome and reflecting upon the result, while collecting data about the situation and actions (Davison 2001). Different action researchers describe different cyclical processes, but the fundamental elements and issues are similar (e.g., Susman and Evered 1978; Davison et al., 2004; Checkland and Holwell 1998: Baskerville and Wood-Harper 1996). The action cycles in this study follow the approach presented by Davison (2001): problem diagnosis, action planning, action execution, observation and reflection.

The action research project presented in this paper involves an in-depth investigation of how the groupware application BSCW was adopted by a geographically dispersed project group. As previously explained, this team was participating in a part-time master's degree education that required project work. The teachers were initially concerned about their experiences with students who were less active than others (and sometimes inactive), especially in the gaps between the campus seminars. This caused projects to begin late, thus increasing the difficulties of teacher supervision. The teachers saw the introduction of technology as a possible way to increase student activity between seminars, providing more time for critical reflection and learning. There were two action cycles in the study. One spanned the period from September to January and the other from January to April. All data sources for the two action cycles of the empirical study are presented below:

Initial activities to establish contact and create a contract agreement, September 2001

1. Presentation of research interest to the teacher group
2. Document analysis of a project proposal for applying groupware to the master's programme, as made by the teachers to the institutional board
3. Interview with the key author behind the project proposal
4. Presentation of research interest to the students at a weekend seminar in September. One group volunteered to participate
5. Document analysis of the book: A different way to university: "Report concerning the master's programme in educational studies at Open University" (Christensen 2000)

P. Bjørn, A. Scupola & B. Fitzgerald • 39

6. Document analysis of: Master's in Adult Education (Master i Voksenpædagogik), Roskilde University, Department of Educational Research

First action cycle: Problem diagnosis activities with the teacher group, September 2001

1. Diagnosis of problems using mapping techniques
2. Articulation of the pedagogical practice using Dead Sea Scrolls
3. Investigation of how IT might help resolving problems
4. Presentations on the possibilities to support group work through IT
5. Summary of workshop given by a teacher
6. Diary notes made by the researcher before and after the workshop

First action cycle: Workshop with the teachers' group, November 2001

1. Observation of their discussion concerning a new description of the master's programme
2. Document analysis of the official rules and content of the master's programme
3. Facilitation of discussion on IT use in the master's programme

First action cycle: Planning intervention activities, November 2001

1. Document analysis of the group's initial project proposal
2. Diary notes concerning the research purpose in general, the purpose of the first intervention activity, and specific planning activities
3. Technical preparations, including passwords etc. for BSCW

First action cycle: Intervention activity, November 2001

1. Presentation of the purpose of the activity for the group
2. Questions for the group to discuss, creating common ground while planning and coordinating the project, eg.: 'What are your expectations for this group work?', including decisions concerning time, collocated and mediated collaboration; 'What are the concrete collaborative activities of the project?', including decisions concerning meetings, working papers, readings, empirical work, analyses, how often to log on BSCW and what it mean to log on; 'Which kind of deliverables will there be, and when should they be finished?' and 'How should structures created within BSCW support your work?'
3. Presentation of an example of a project contract, a project plan and different examples of folder structures.
4. Document analysis of summary made by the group, including its plan, project contract and folder structure
5. Hands-on introduction to BSCW
6. Tape recordings, drawings, pictures and maps were used to capture the rich activities
7. Diary notes made immediately after the session, including evaluation of different interventions

40 • P. Bjørn, A. Scupola & B. Fitzgerald

First action cycle: Observation activities, December 2001-January 2002

1. Observations of the use of BSCW
2. Diary notes

First action cycle: Evaluation, **Second action cycle**: Diagnosis and planning activities, January 2002

1. Diary notes made before the session
2. Questions for the group comparing the decisions negotiated in November to actual experience between November and January
3. Facilitation of articulation of specific work practices
4. Tape recording of the session
5. Diary notes made immediately after the session
6. New planning for the project
7. New hands-on introduction
8. Revising folder structure
9. Technical explanation document about the functionality of BSCW

Second action cycle: Observation activities, January-March 2002

1. Observation of the use of BSCW
2. Status session in March 2002 in which the group received questions to articulate and in which they evaluated their collaborative practice from January to March
3. Tape recording of activity
4. Diary notes made immediately afterwards and as follow up questions using BSCW

Second action cycle: Reflective session with the group on the groupware adaptation process as a whole, April 2002

1. Observation of the use of BSCW
2. Diary notes made before and immediately after the session
3. Questions for the group
4. Tape recording of the activity

Second action cycle: Document analysis, May 2002

1. The group's description of the project period, including their engagement with the action research project officially handed in to the master's programme
2. The project report made by the group

Second action cycle: History interaction logs of the actions performed in BSCW

1. Calculation of the interaction logs comprising the number of actions made within each folder and sub-folders of BSCW, divided by month

Theory plays an important role in action research. Even though some action research projects begin by being theory-free, explicit theorising is necessary if

P. Bjørn, A. Scupola & B. Fitzgerald • 41

a grounded theory does not emerge during the diagnostic stage (Davison et al. 2004). During the actual performance of the action research project presented in this paper, the theoretical perspective was informed by earlier research on groupware adoption by researchers such as Grudin (1994), Karsten (1999) and Orlikowski (1992). In the course of the analysis of the empirical observations, the research interest remained on groupware adoption. The theoretical perspective, however, changed and became informed by the theory of technological frames (Orlikowski and Gash 1994). This influenced how the data was re-examined and analysed. The theoretical standpoint informed the empirical observations and drew attention to specific aspects of groupware adoption. The action research approach during the data collection process brought in high quality material, including views of the practical situation from different perspectives (documents, workshops, interviews and observations) at different points in time. This data provided opportunities for additional analysis.

The empirical observations presented in this paper were analysed by applying the theoretical perspective of technological frames as a lens for identifying the technical and social factors that influence the expansion of frames. The analysis comprised re-examinations of all the audio transcripts, field notes, pictures, drawings and observations collected during the action research process, focusing on all aspects that impacted on groupware adoption related to the nature of the groupware, the strategies for adoption and the technology-in-use on a day-to-day basis. The focus of the analysis was to identify the empirical observations that showed how the actors changed, modified, aligned and expanded their technological frames concerning groupware.

The action research approach applied in this paper began by creating a researcher-client agreement. It involved two cyclical processes of action, based upon the principles of change through action and learning through reflection. It was guided and informed by complementing theories at the data collection and analysis stages alike. The approach described in this paper thus meets the criteria for action research presented by Davison et al. (2004).

6   Analysing the Groupware Adoption Process

This analysis is divided in two main sections, one for each action cycle of the research project. Sub-sections for each action cycle focus on its different activities: problem diagnosis, action planning, intervention, observation and reflection. Finally each main section ends by presenting the technological frames of key actors in the particular action cycle.

6.1 The First Action Cycle: September to January

The initial phase of the first action cycle, from September to November, involved the following activities: establishing contact with the organisation (the master's degree programme); producing a researcher-client agreement (Davison et al. 2004); understanding the problems experienced by the teachers concerning students' inactivity between campus seminars (problem diagnosis); planning the intervention to include finding a student group that was willing to participate (action planning); conducting an introductory workshop with the group (intervention); and producing final observations on the use of groupware and the evaluation of the actions (reflection).

Problem Diagnosis. The master's degree programme has existed since 1990. In the summer of 2001 the teachers proposed a pilot project to apply IT to the education. In a proposal submitted to the institutional board they argued that 'applying net-based teaching supplementing other teaching activities would be obvious since the students live far away from campus and each other and the geographic distance is a barrier for the project work in groups' (translation from the Danish proposal). Activities to diagnose the problems in the first action cycle took the form of interviews with the key author of the proposal and two workshops involving the whole teaching group for the programme. At the workshops we facilitated the teachers to articulate the problems they had experienced, using mapping techniques (Lanzara and Mathiassen 1985).

The primary problem they identified was that students were less active between the on-campus seminars, causing project-related work to begin in April or even in May, when it originally was intended to begin in November. Groups that started their projects too late created a problem for the teachers, because they made project supervision more difficult. The teachers wanted to change this situation and believed that an IT conferencing system might contribute to the solution. Their knowledge about this kind of technology and its use was limited. They selected a conference system called Magenta[1] on the principle that it was simple and that both students and teacher did not have to invest time and effort in learning how to use it. After examining the functionality of Magenta, we questioned this choice of IT system. Even though it fully lived up to their requirement for very low functionality, their choice did not reflect any thinking on the kinds of student activity that the system should support. They had given even less consideration to how the system should resolve the problem of students' inactivity between on-campus seminars.
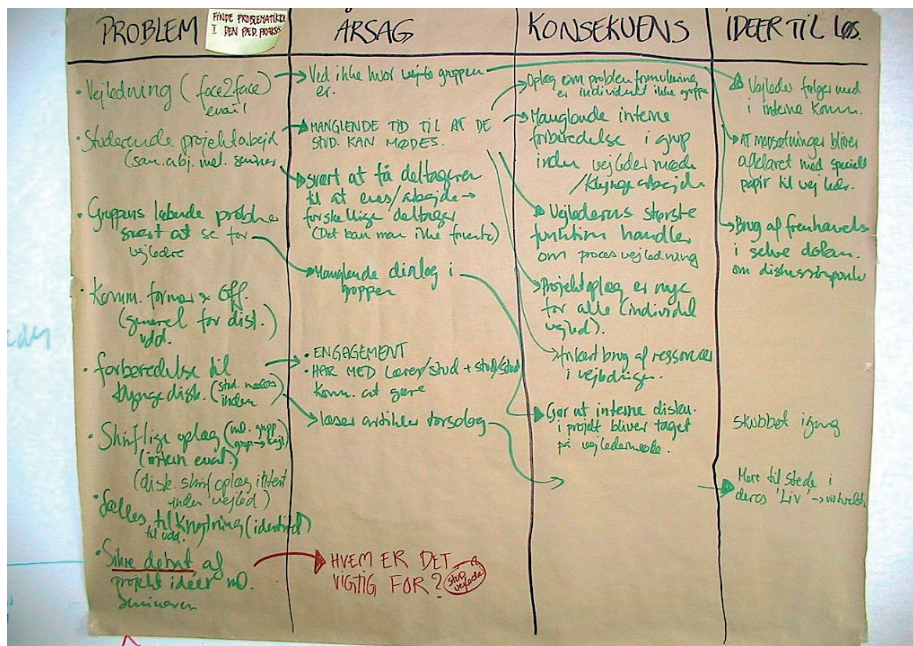
Figure 2. Diagnostic mapping of problems experienced by the teachers and articulated at the second workshop

The teachers agreed with the researcher on these matters, but by that time they were unable to change the decision to use Magenta as the main supporting technology. Instead the teachers decided that, if one group would voluntarily participate in the adoption of another system which would support the group's project work in a better way, we could facilitate that group in their adoption process. BSCW was chosen as the supporting technology because it was already available from the IT department of the university, while being well suited to facilitate group work.

Action Planning. At the first on-campus seminar in September the action research project was presented to the students and one group volunteered to participate. The researcher offered to introduce and facilitate the use of groupware, including building a shared ground and providing ongoing suggestions for improvements to their collaborative process. In return the students should commit to participate in four workshops/reflective conversations. The students were free to reject the system at any time. The group members were asked to write an email about their individual experiences with IT, which was used to plan the first intervention in November.

44 • P. Bjørn, A. Scupola & B. Fitzgerald

Intervention. In November a six-hour workshop was conducted on a Friday evening between 6:00 pm and midnight on the day before an on-campus seminar. The aim was to introduce BSCW to the group by providing hands-on training and demonstrating the functions for coordinating, communicating and exchanging documents. The group was also facilitated to negotiate their common ground (Olson and Olson 2000) on the content and the goal of the project. The workshop activities were recorded using wall-graphs (Simonsen and Kensing 1997) and tape recording. In addition, an entry was made in the researcher's personal logbook just after the session.

This introductory activity resulted in a contract among the students, covering preparations for the project work, a project plan, and a designed BSCW workspace comprising a folder structure based on the project plan. One student remarked that after this introductory workshop they all felt more on track with the project, than the year before.

> I think we all had a feeling of being far more on track than the year before. It was a relief to have an overview of the project and process even though it might have been an illusion. (...) The hard thing about this part-time education is that you sometimes lose your feeling for the project and then something like this [BSCW and plan] is extremely good to have. (Group member in January 2002)

The introductory workshop in November thus induced a feeling that BSCW would extend their capabilities for remote collaboration. At this workshop students were informed about new technological opportunities and how to relate the BSCW functionality to their actual practice. This new knowledge of technological opportunities expanded the students' technological frames in relation to technology strategies. None of the members had heard about groupware technology before, and remarked that email had worked OK in former projects, even though they had experienced difficulties in keeping track of various versions of specific documents. After the workshop the students perceived that the primary motivation for using groupware was to reduce the effort of coordination.

By creating sub-folders in BSCW based on the negotiation of the project content and plan, the group was facilitated to embed their future work practices into the structures of the groupware system. This process supported the alignment of the participants' understanding of how to deploy the system, thus facilitating the development of congruence among their individual technological frames in relation to daily use of groupware. Whereas their earlier technological frames related to the nature of technology in project work centred on email, now they included knowledge of groupware. Additionally, the group

P. Bjørn, A. Scupola & B. Fitzgerald • 45

members' frames towards groupware were to some extent in balance, since all the participants had taken part in negotiating the folder structures.

Observation. Within the first action cycle, the period from November to December was characterised by very low, or almost no, interaction within the group. Due to the members' daily work and family routines, the group did not engage in any kind of collaboration in this period. The members did log onto BSCW to see if anything has happened. Two small discussion notes were added, but none were answered. Then between Christmas and New Year the group held a telephone meeting to get the communication started again. The main purpose for this telephone meeting was to discuss and coordinate the production of a synopsis, which they should send to their supervisor before meeting him in January. Using the telephone they also discussed how to coordinate and exchange different versions of the synopsis and they decided *not* to use BSCW, but email instead. When asked in January why they took this decision a group member explained:

> The thing with the BSCW is that when the working process is not continuous (...) then nothing happens (...) so it becomes like a stranger out there (Group member in January)

Participants in part-time vocational education use their free time to study. Therefore the process will never be continuous and this makes it difficult to achieve sustained use of groupware technology. The motivation to use BSCW decreased in December because the focus in this period shifted from learning how to use the technology to creating the content of the synopsis. Thus, the barrier of learning and enacting the functionality of groupware in practice was problematic. The result was that the group chose to rely on the more familiar email technology.

Reflection. In January a two-hour reflective session with the group was conducted using wall-graphs and rich-pictures (Checkland and Scholes 1990), and the activity was tape-recorded (figure 3). The aim of this session was to evaluate the use of the groupware system in the period from November to January, and the researcher encouraged the group to articulate the *actual* collaboration process as experienced from November to January. Knowing they had used email for coordinating the synopsis, the main question was whether this 'more traditional' technology was successful. If it were, then the inevitable question would arise as to the need for the groupware system. However, it transpired that the use of email for coordination had failed. The group did not actually realise this before the reflective session. They had emailed the synopsis to their supervisor two days before the reflective session and they all thought they shared a common understanding of both the content and the proc-
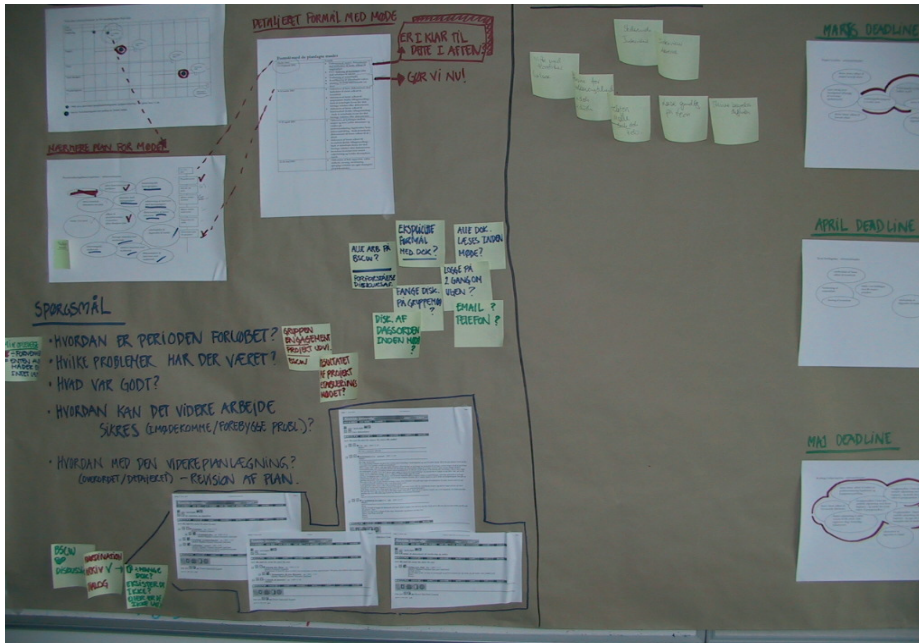
Figure 3. Wall-graphs

ess by which the document had been produced. However, this was not the case. The following discussion took place at the reflective session:

> Thomas: I think there is something missing here on the first few pages [pointing at a printed version of the document].
>
> Emma: Is this not the last version you sent?
>
> Thomas: No it is not.
>
> Emma: The one you sent a couple of days ago?
>
> Thomas: The one we mailed to Adam [the supervisor], the one we called version 4, the one Lisa had written on – unfortunately I don't have a printed version because my printer isn't working, but Lisa had put mine and hers together; it is about 6-7 pages long...(...) (Group discussion, January)

This discussion continued and they became increasingly frustrated about the situation. They lacked a printed final version and in the end they decided to contact the supervisor to check if he had the right version. In addition they began discussing the email coordination process, and soon realised that they lacked a shared understanding of the underlying process. The group thus found itself in a new problematic situation that influenced a change in its

P. Bjørn, A. Scupola & B. Fitzgerald • 47

members' perspectives on email. This, in turn, affected their perception of groupware.

Technological Frames After The First Action Cycle. The technological frames of the teachers group after the first action cycle were influenced by the activities planned and guided by the action researcher—especially with regard to their perspective on the nature of groupware as in the functionality and capabilities provided by the technology. Where they initially perceived that they needed 'low functionality', reducing time for learning the technology, they acknowledged at the end of the first action cycle that the technology also should support particular collaborative activities in order to be useful. The teachers' perspectives on the strategies for groupware became more explicitly articulated—preventing late project starts and thus improving the conditions for supervision. The day-to-day use of the groupware system to support group work was still perceived by the teachers as an issue for the students themselves.

The technological frames of the student group related to the nature of the technology changed by the end of the first action cycle. Initially the group had no knowledge about groupware but, influenced by the intervention activities, it had now been introduced to functionality that should be relevant for future collaboration. The students' primarily motivation for using the system was to decrease their effort in coordination. At this time the students still did not have any experience of technology-in-use but, guided by the researcher, they had negotiated how groupware would support their activities. These negotiations were not based on experience, but on assumptions about their future collaboration.

The technological frames of the action researcher were not changed during the first action cycle, particularly because the role of the researcher in this action cycle was to influence the technological frames of the student group and the teachers. So far none of the researchers' initial assumptions of groupware support of problem-oriented project work in geographically dispersed groups were challenged by the technological frames of these two sets of actors. The following table summarises the technological frames after the first action cycle.

	Teachers	*Students*	*Action researcher*
Nature of technology	Technology must support particular collaborative activities between the students to be useful.	Support of coordination, shared archive and planning.	Groupware supportive of collaboration in project groups in education needs to have functions such as coordination, shared archive, version control and negotiations.
Technology strategies	The motivation behind groupware is to make the project begin earlier, thus making the supervision process easier.	Decreasing effort of coordination.	Geographically distributed groups have difficulties collaborating. Groupware can provide opportunities for collaboration, reducing time for coordination, while increasing time for learning and negotiation.
Technology-in-use	The use of groupware technology in the project groups is up to the students themselves.	Negotiated use of technology related to their subject matter, but no practical experiences with day-to-day use.	The group should be assisted to negotiate common working procedures for groupware, including how, why and when to use it in specific situations related to their project.

Table 3: Technological frame of key actors after the first action cycle

6.2 The Second Action Cycle: January to April

The second action cycle began where the first one ended at the reflective session in January and ran to the end of the action research project in April. The second action cycle comprised problem diagnosis of the situation in January, planning of new actions to resolve the problems experienced by the group

P. Bjørn, A. Scupola & B. Fitzgerald • 49

related to us of BSCW, intervention activities, observations of the effects of the new actions, and finally reflections on the new intervention activities in relation to groupware adoption.

Problem Diagnosis. When the group members and the researcher together reflected upon the group's collaboration between November and January it became clear that the problems experienced by the students were related both to email and groupware. The main problem with email was found to be the difficulty of keeping track of the various versions of the documents they exchanged. This had also been a problem in previous projects. The reason for not using groupware was mainly the lack of motivation to make an effort to learn the groupware functionality during the process of constructing the synopsis. Because they had not undertaken shared collaborative activities immediately after the initial introduction to BSCW, the students had not become familiar with the functionality of BSCW while it was still fresh in their memories. The students had not adopted these functions on a regular basis immediately after their introduction to groupware before new situations emerged and put them under time pressure. Pattern behaviour of technology is highly influenced by the initial stage of use, since initial behaviours typically determine the use of technology over time lasting the entire project (Tyre and Orlikowski 1994; Huysman et al. 2003).

Action Planning. The researcher and the group planned new actions aiming at solving the problems that had been identified in groupware adoption. These activities were intended both to facilitate the students in learning the functionality of BSCW ensuring immediate and regular use while changing the technology-behaviour patterns within the group. The activities included concrete actions by the researcher and new commitments from the students. As one group member said:

> Now we need to get past these [feelings towards BSCW] and say; OK it is not that difficult and instead realise that this [BSCW] actually makes it easier to get access to each other. I think that what we need is to commit to the system. (Group member in January)

Intervention. The first activity to support the group's BSCW adoption was a new hands-on introduction to the system's functions. This was structured around questions from individual group members on how to perform specific tasks. During this process the members realised that they actually remembered the functionality of the system quite well. In this way the individual technological frames towards groupware were not established in the second cycles, but were instead expanded as the group learned more about the nature of the system.

50 • P. Bjørn, A. Scupola & B. Fitzgerald

Secondly the researcher produced a document that described the functionality of the system, and a second document that described three scenarios for using the BSCW for coordination. In addition, a direct notification feature in the BSCW was turned on in order to alert the group members to relevant events occurring in the system. Finally, the researcher set up a discussion forum called the weekly logbook, where group members could write notes about the project, together with personal information and other issues they wished to mention. The main purpose of the logbook was to encourage regular use. The students were therefore advised to write an entry in the logbook each week.

Observation. Besides observing the actions in BSCW, a status session was also conducted in March. The aim of this session was to gather information about how the group perceived its collaboration and use of groupware at that point in time. The researcher was not present at this session, but had provided the group with a list of questions to discuss. The group recorded their conversations and this data were later transcribed and analysed. The questions the group discussed were divided into two types. One related to the evolution of the project itself and another aimed at understanding the role of BSCW. Examples of questions are: Which kind of documents do you have at this time? Are there documents not placed in BSCW? Describe what you have been doing in the past period and how BSCW or other kinds of technology (like phone and email) have been used?

Between January and March the situation for the group had changed in two important ways. Firstly, they had managed to adopt BSCW into their collaborative practice and secondly, the group had developed a shared understanding of how the project was taking shape by using the actions within BSCW to interpret each other's individual activities. This was evident by the large numbers of actions within the system, e.g., revisions of folders, uploads and downloads of documents and weekly notes in the logbook.

The actions depicted in Figure 4 comprise creations, revisions and deletions of folders, documents, URLs and notes made within BSCW during the whole period from November to June. They do not include reading or downloading. The actions in November include those made during the hands-on introduction (37 actions). Out of the remaining 25 actions in that month, 20 actions were made by the researcher concerning technical guidelines, such as how to perform specific tasks like uploading documents or using the version control. In November, the participants made only 5 actions after the first

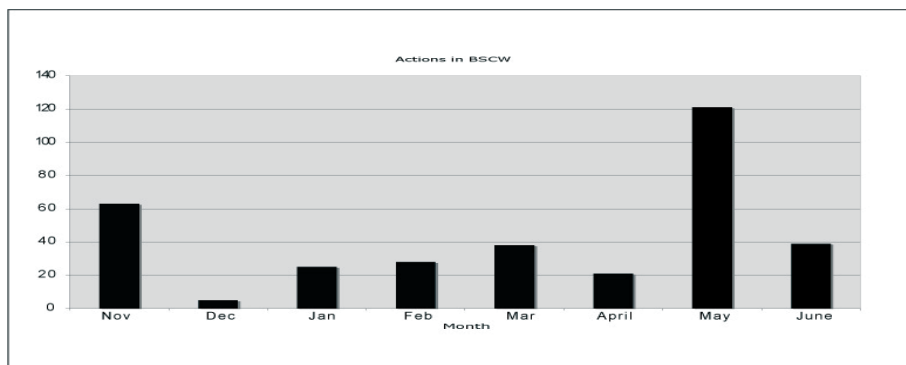P. Bjørn, A. Scupola & B. Fitzgerald • 51

Figure 4. Number of action made within BSCW illustrated by month

hands-on introduction. In Figure 4 we see the major difference between the numbers of actions made before and after the intervention in January.

The group had managed to reduce the effort required for coordination by using the groupware system during the second action cycle. While in January almost all the time at the campus seminar was spent discussing the status of the project, this was a minor issue in March. Surprisingly, a wider use of the system was also detected. In fact, the weekly logbook, originally established to encourage regular use of BSCW, had brought additional visibility to the social dimension of the collaborative situation by providing a social context for interpretation of each other' actions. This is shown, for example, by the following extracts:

> Lisa: I think this weekly logbook has been very good, because I have had a good sense of where you all have been – especially you Thomas, who have written all about your illness.

> Emma: It makes it much more captivating to go in and read stuff like this too.

> Thomas: Yes (...) because it gives you a good feeling of what is going on. (...) The constant response. It is especially good in these kinds of distance projects.

> Lisa: Sometimes you get hung up with work and lose contact with the project...

> Emma: (...) you know you have it all in BSCW (...) it gives you a sense, psy-chologically, that there is a project forming. (Group discussion in March)

The weekly logbook had bridged the geographic distance between the group members, ensuring that the geographic distance did not lead to social distance. Social and people-centred issues have been found important when researching group collaboration (Steinfield et al. 1999; Prinz 1999; Tollmar et al. 1996; Schmidt 2002). Small daily interactions around the coffee machine or water

cooler help members of collocated teams to get a sense of each other. The lack of such information in geographically distributed teams can affect group morale due to possible misunderstandings and misinterpretations (Cramton 2001). The group had found that their use of groupware provided a new capability for their collaboration by mediating information similar to "information received when walking along the office floor" (Prinz 1999, p. 2).

Reflection. The last activity conducted with the group was a reflection session held in April five weeks before the group turned in the final version of the project report. The reflective session was organised as a one-hour conversation, which was tape recorded and later transcribed. We found that the collaborative practice of the group had been transformed by groupware. One example was that a telephone meeting originally planned between January and March had been cancelled because the group preferred using BSCW instead. When asked why they cancelled the telephone meeting, the group explained that it was too expensive. The cost of a telephone meeting had not been an issue between Christmas and New Year because they needed it for coordination, but after BSCW was adopted into their practice, the need for the telephone was reduced. Also the email direct notification feature transformed the practice. This feature supported visibility and awareness of the actions conducted within the BSCW system, since each time a member wrote, revised or moved objects within the system, an automatic email was sent to all members to inform them. Each member could therefore monitor when others had made a contribution. When the participants made their weekly entries to the logbook, their actions generated email notifications. This made a huge contribution to the successful adoption, because it caused the group to use the system functionality regularly. The weekly logbook also facilitated spontaneous and informal interaction, serving as an informal discussion forum with no prescribed usage or content. Spontaneous interaction has also in previous research been found to support collaboration in virtual teams (Hinds and Mortensen 2005).

At the reflective session the group members characterised their experience of the project work as much more calm than in earlier projects and they had a strong feeling of confidence that they would finish on time with a good result. Additionally they stated that the researcher's interventions had influenced the process in a positive way. As one group member said:

> [Without the researcher intervention adopting groupware] we would not have come this far, especially in our heads. Maybe in respect to the written documents, but the feeling of coherence around the project would not have existed. This is the first time I feel, we are in control. (Group member in April)

Aligning work practices and technology requires articulation of the practice. Asking questions related to the collaborative processes initially as well as dur-

P. Bjørn, A. Scupola & B. Fitzgerald • 53

ing their project helped the students to articulate their work practices. In this way two goals were achieved. First it supported the group by developing a common ground (Olson and Olson 2000) for its project and second it helped build actual work practices based on technology use instead of speculation about the potential use of groupware (Suchman 1983). The students perceived both goals as important for success in the project work process and in groupware adoption. The nature of BSCW was also vital for adoption. Besides providing a shared repository for the documents, BSCW additionally created a feeling of a 'backbone' of the project embedded in the folder structures. BSCW had become a common information space, because group members through negotiations had constructed shared meanings related to the shared information items and their locations within the groupware system (Hertzum 1999).

The group was of the opinion that they would not have adopted BSCW without the researcher's interventions. First, none of the participants were even aware of the existence of groupware technologies, so the intervention provided them with knowledge of the new technological opportunity. Furthermore, one group member explained that his anxiety towards technology would have caused an immediately rejection, if he had not known that someone who cared about their project and their use of groupware was available to answer his questions. Additionally, two of the group members told they had been 'bragging' about their use of the system, showing it to friends, family and colleagues when asked about their project. They were proud of the system, which also affected their view of technology in their daily jobs. One group member was planning to adopt groupware for collaboration with colleagues in her day job. Another group member explained that she had advocated that colleagues in her workplace should remember to store common documents at the X-folder.

Technological Frames After The Second Action Cycle. The technological frames of the teachers had not changed much in the second action cycle, primarily because there were no special activities arranged for the teachers in this period. The teacher who supervised the group that adopted BSCW, however, asked regularly how the members' use of groupware was going. Since the group was enthusiastic about the system and also wrote about its experiences in the official evaluation of the project, the teachers came to believe that the master's degree programme should extend the use of technology.

The technological frames of the students changed dramatically in the second action cycle. Concerning the nature of groupware technology, the students had expanded their view to include functions beyond coordination and shared archive. The additional capabilities that BSCW provided to support the students' collaboration were visual representation of the project (as embedded in

the conceptual folder structures within the system) and the possibility to mediate social relations. The expansion of technological frames related to the nature of groupware also expanded the category of strategies for adopting groupware. Now the students were not only motivated to adopt groupware for coordination and shared archive, but also because the system would provide new capabilities that improved their collaboration—supporting the exchange of informal social information and providing a visual representation of the project. After the second cycle, moreover, the students' understanding of the day-to-day use of BSCW was changed from being solely at a theoretical level to comprise concrete experiences with groupware in particular contextual collaborative situations.

Just as the action researcher had greatly influenced the technological frames of the students in the second cycle, the students' perspectives on groupware also influenced the technological frames of the action researcher. As regards the nature of the technology, the technological frames of the action researcher after the second cycle included not only shared archive and coordination, but also visual representation of the project and the mediation of social relations. This further expanded the technology strategies, since the motivation for adopting groupware now included more possibilities: developing social coherence among geographically dispersed actors by providing a platform for exchanging social information and giving them a visual representation of the project. Lastly, the action researcher's understanding of technology-in-use was based upon negotiation and re-negotiation among participants, developing a common understanding of workflows and the use of technology in particular situations (table 4).

7 Discussion

The identified factors that influence the expansion and alignment of participants' technological frames towards groupware are both technological and social. The technological factors comprise the nature of the technology in relation to the new capabilities that it offers. The unanticipated capabilities that groupware provided in this study were the visual representation of the project embedded in the emerging structures of BSCW and the opportunity for mediating social relations. Both of these factors supported the group in the transformation of BSCW to become a common information space (Hertzum 1999). The participants perceived both of these new capabilities as positive influences for groupware adoption. BSCW had provided a shared workspace where social actions were propagated and 'objects-of-work' were operated upon

	Teachers	*Students*	*Action researcher*
Nature of technology	Technology must support particular collaborative activities between the students to be useful.	Groupware functions include support for coordination, shared archive, visible representation of the project and mediation of social relations.	Groupware functions include support for coordination, shared archive, visible representation of the project and mediation of social relations
Technology strategies	The motivation behind groupware is to make the project begin earlier, thus making the supervision process easier.	The motivation behind groupware adoption is to reduce coordination effort, having more effective collocated meetings, exchanging social information while being a visual representation of a project taken form.	The motivation to adopt groupware includes the reduction of coordination efforts, increasing time for reflection and learning, as well as support for developing social coherence among geographically distributed actors by providing a platform for exchanging social information and giving them a visual representation of the project
Technology-in-use	The use of groupware technology in the project groups is up to the students themselves.	Concrete experiences with use of groupware in particular collaborative situations of the group work.	Implementation of groupware on day-to-day basis is based upon a negotiated and re-negotiated understanding of work-flows and collaborative activities developed through the participants' experiences of regular use and negotiation in reflective episodes.

Table 4: Technological frames of key actors in the end of the second action cycle

56 • P. Bjørn, A. Scupola & B. Fitzgerald

(Ngwenyama and Lyytinen 1997). This was perceived as a new capability, useful for supporting collaboration. The use of BSCW transformed the group practice by creating a representation of the project that induced the feeling that the project was taking form. The project was right 'there' in all the folders and documents located in the group's common repository related to a shared meaning. Moreover the use of the weekly logbook provided the group with a sense of both task-oriented and social-oriented awareness related to their mutual work (Prinz 1999). The logbook provided the 'group members with information helpful for making sense of others' actions necessary to interpret others' actions (Steinfield et al. 1999, p. 84). The logbook contained extra socially significant information such as information about group members' health and family situations. Exchanging social information supported a feeling of coherence within the geographically dispersed group. The weekly logbook also facilitated asynchronous casual social encounters through the simultaneous hosting of coordination activities and social interactions. Spontaneous communication has previously been associated with a stronger shared identity and shared context in virtual teams (Hinds and Mortensen 2005). This finding is also supported by our data. Groupware adoption thus transformed the collaborative practice of the group, resulting in unanticipated social effects and a much wider appropriation of BSCW than initially intended (Berg 1998; DeSanctis and Pool 1994). We also found evidence that the new capabilities of groupware were greatly appreciated by the participants, affecting groupware adoption positively (Robinson 1991).

There were three main social factors influencing the expansion of technological frames. First the introductory session afforded knowledge about the new technological opportunities by introducing the groupware functions. Here the functionality related to the future practice of the group. Second the initial negotiation of goal, aim and plan for the project supported the group in developing a common ground (Olson and Olson 2000). The initial introductory session presented a new window of opportunities (Tyre and Orlikowski 1994) by including negotiations of the goal, aim and plans for the project and by basing the first folder structures upon the insights from these negotiations. In this way the introduction to the technology was related directly to the project, supporting the group's understanding of how groupware could be useful to mediate their distributed activities. This served as a link between groupware and practice. The third social factor that influenced groupware adoption was the reflective episode two months after the initial introduction. When the group attempted to collaborate using the system after this time lapse, their willingness to learn the new technology seems to have decreased. They rejected the groupware system and used familiar technologies instead. This observation suggests that collaborative activities conducted immediately after the intro-

duction session strongly influence the subsequent patterns of technology use. This is also supported by earlier findings that it is difficult to change patterns of technology use and that participants often get stuck in unproductive work patterns (Huysman et al. 2003; Tyre and Orlikowski 1994). The reflective session provided the group with the opportunity to articulate their work practice experiences while re-evaluating both the collaborative practice and their use of technology.

Our empirical observations provide strong evidence that groupware adoption would have failed without the reflective session in January. That session was a disruptive event because the group realised that their use of email to coordinate the project documents had not produced the expected results. Disruptive event is previously been found to guide the alignment of technology in virtual teams (Majchrzak et al. 2000). The reflective session provided a new window of opportunity. This new window was exploited immediately by the new actions planned and executed by both the group and the researcher. Disruptive events often provide participants with the ability to evaluate their work practices critically, thus increasing their willingness to revise, modify and adjust work practices, including their use of technology (Tyre and Orlikowski 1994). In addition, the work practices immediately after the reflective session were characterised by activities performed within the groupware system, especially in the newly created weekly logbook, which were in stark contrast to the inaction that followed the initial introduction session.

Socially related factors (e.g., the reflective session) and technology related factors (e.g., the weekly logbook forum) both supported the expansion and alignment of the participants' technological frames, leading to the adoption of groupware. Without these factors it is most likely that the group would have been unable to adopt groupware to mediate distributed yet interrelated activities.

8   Implications

By conceptualising groupware adoption as the alignment and expansion of participants' technological frames we must focus on the participants' particular interpretations of the technology and on its role in settings that include nature, strategies and use of technology (Orlikowski and Gash 1994). The process of expanding technological frames must be understood as a continuum with varying degrees of technology adoption. Initially, in our group, the participants' technological frames were aligned and comprised the use of email and
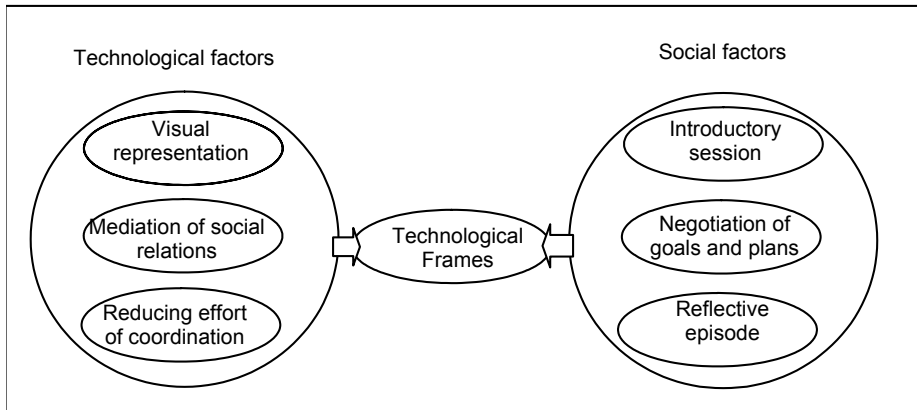
Figure 5. Technological and social factors expanding participants' technological frames

phone. The assumptions, expectations and knowledge about the technological opportunities for mediating group collaboration did not include groupware. Then, after the first intervention, the technological frames of the participants were expanded in terms of new knowledge about technological opportunities, including the nature and strategies of groupware. Nonetheless, the groupware was not fully adopted. The expansion was only in terms of knowledge concerning new opportunities, even though the groupware functionality had been introduced in a context of future collaborative actions. It was assumed that groupware could support their collaboration and they expected it to do so, but it failed. Participants had seen the artefact as having potential to support their collaboration (Mogensen and Trigg 1992).

The participants' interpretations of groupware technology were modified in the reflective session in the first action cycle, moving towards the next level of technological frames expansion. The reflective session provided a new window of opportunity for changing the unproductive patterns of collaboration (Tyre and Orlikowski 1994). Here the technological frames towards groupware not only contained knowledge about new opportunities, but also included articulation of the non-use of groupware and concrete experience of activities mediated by email. In this way the non-use of groupware was related to previous practical collaborative experiences, instead of to proposals for future activities. The technological frames were thus expanded from mere speculative knowledge about new opportunities to a degree of in-depth articulation of actual collaborative work practices and use of technology. The technological frames were no longer just related to plans for collaboration, instead they were related to situated actions in collaborative practice (Suchman 1987). Then, in

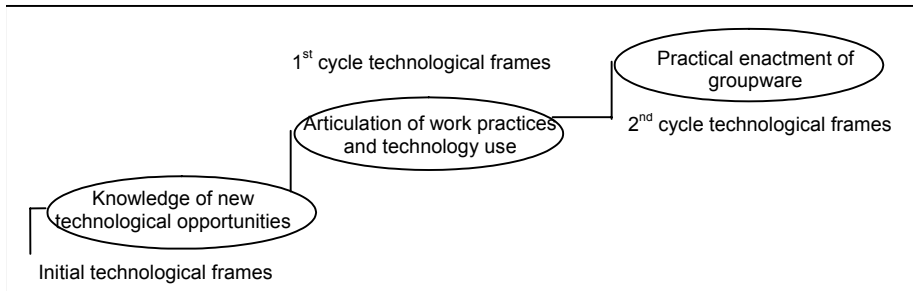P. Bjørn, A. Scupola & B. Fitzgerald • 59

Figure 6. Expanding technological frames at three steps

the problem diagnosis stage of the second action cycle, the in-depth articulation of experienced practice was related to the possible future use of groupware. Here the articulation of concrete work experiences and use of technology facilitated the alignment of the technological frames of the participants. The participants recognised the potential of the artefact (Mogensen and Trigg 1992). The difference between participants seeing groupware at the initial stage compared to the recognition at the reflective session is participants' recognition was embedded in practical experiences while the initial 'seeing' was based on assumptions of the potential of groupware.

The third level of technological frame expansion concerned the practical enactment of groupware. Here groupware is appropriated and used to mediate the interrelated activities of the group. This step requires commitment from the participants and alignment of the individual technological frames on key categories. Here the technological frames of the participants are expanded from the degree of knowledge about the technology through the articulation of concrete work practices and technology use towards practical enactment of groupware. It is only during this third level of expansion of technological frames that the use of groupware becomes embedded into the social practices. At this stage the participants experience a balance between how they articulate their practices and their use of technology so they can own the artefact (Star and Ruhleder 1996; Mogensen and Trigg 1992). These observations suggest that groupware adoption can be conceptualised as an expansion and alignment of technological frames at three levels: knowledge of new technological opportunities, articulations of concrete work practices and technology use, and the practical enactment of groupware.

Figure 6 illustrates the three levels of technological frame expansion, representing three steps towards groupware adoption. Initially in this research project we tried to take the first two steps at the same time, attempting to establish a close tie between the introduction to groupware and the actual

practices of the group. Our empirical observations illustrate, however, that this initial connection between practice and technology was based on speculation about future work and not on concrete experiences. This suggests that it is difficult, if not even impossible to introduce groupware and to establish a new practice with only limited experience of group work practices. Until the breakdown of email coordination the group did not have a group work practice and the breakdown resulted from the failure of a previous technology to support the first concrete group task in a proper way. The experience of breakdown provided the group with an understanding of how group work practice is something more than just email correspondence. This triggered the group's understanding of potential future work practice and the need for groupware, such as BSCW, to support it. Finally our empirical observations suggest that the third step of groupware adoption (practical enactment) should be taken immediately after the second step, since delays are damaging for the adoption process.

One could argue that if the collaborative process immediately after the initial introduction had not been an interruptive period, but instead consisted of interrelated activities, the groupware adoption process would have looked different. However, we would argue with reference to Majchrazak et al. (2000) that, in order to solve misalignment between technology and practices, it is essential to foster re-evaluation to help achieve groupware adoption. Thus we argue that, even with a large number of activities immediately following the initial introduction, there would still be a need for reflective sessions to provide an opportunity to re-evaluate the collaborative practice and technology use. The links between groupware use and practice call for articulation and reflection that are grounded in actual experiences.

Our findings in this paper suggest that adopting groupware in geographical distributed project work should be perceived as the alignment and expansion of technological frames related to the nature of technology (the functionality that is required), technology strategies (the motivation for adopting groupware) and technology-in-use (how should groupware be used in practice). Practitioners might use the three-step model of expanding technological frames to plan the process of groupware adoption. The model suggests that the first step would be to introduce the new technological opportunities for the participants at all three domains of technological frames: nature, strategies and use. During this introductory stage time for negotiations of the subject matter, collaborative process and technology use is essential. Moreover, evaluation activities including re-negotiations of the collaboration process and the use of groupware are important. Finally, practitioners should choose groupware technology appropriate for the particular collaborative process to ensure that the

P. Bjørn, A. Scupola & B. Fitzgerald • 61

functionalities are appreciated by the participants thus expanding group members' capabilities for collaboration.

Like other studies, ours has potential limitations. One obvious limitation is that we only examined a single self-selected group of three participants. One could question whether they were representative of groupware adopters or if they were too interested in, and eager to learn about, the technology. Their attitudes may have influenced the success of the adoption process. We believe, however, that the group members were critically reflective towards technology. They had the opportunity at all times to withdraw from the project with no consequences for their education. In fact, they rejected the adoption of BSCW between November and January. In addition, one of the group members stated explicitly that he was easily intimidated by technology. We would argue that the perspective of technology in the group we investigated was representative of adults attending master's degree vocational education. Another potential limitation of our study is its focus on social and technological factors that are closely related to the social context of education. This excludes other considerations, such as political and economic factors, that might also influence the expansion of technological frames. We acknowledge the existence of the other factors and that our focus in this study excluded factors from social contexts outside education. Our three-step model of groupware adoption should therefore be viewed as a proposed conceptualisation and not as a final statement. New research, including the consideration of factors from related social contexts, is required to complete the conceptualisation of technological frame expansion. Additional research is required to refine and test the conceptualisation. These new studies might expand our understanding of, and definitions for, the different factors that lead to successful groupware adoption, so we can improve the conditions for collaboration in geographical distributed groups.

Notes

1. Magenta is a message board. You can write a text message and read others' text message. There is no possibility to build up folder structures, attach documents, delete or move messages.

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