Network Applications for Group-Based Learning: Is More Better?

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ABSTRACT

Group-based learning is being introduced into many settings in higher education. Is this a sustainable development with respect to the resources required? Under what conditions can group-based learning be applied successfully in distance education and in increasingly flexible campus-based learning? Can networked support facilitate and enrich courses where group-based learning is applied? These questions formed the basis of the motivation for the research project whose main results are presented here. The goals set for the research were the identification of problems associated with the planning, operationalisation, and monitoring of group tasks in group-based learning in higher education, and the identification of networked support options which, in combination with appropriate instructional decisions, have the potential to remedy these problems. The solutions identified were tested in the context of three case studies.

INTRODUCTION

In the research project described here the potential of a number of network options to support group-based learning were investigated, in particular with respect to solving problems in planning, operationalisation, and monitoring group-based tasks (Van der Veen, 2001). The study included three case studies, each conducted over three consecutive years and in a different course setting. In this paper the main points that were learned in each of the cases are presented. We asked: which of a set of 12 problems in planning, operation-alisation, and monitoring were solved? Was it the network support or the instructional design that made the difference, or is the solution to be sought in a combination of the two? What were the key factors for success or failure in

each of the case studies? What future developments can we expect? Throughout this paper a theme which developed during the research continually arises: *When selecting a network support option, is the key choice that of simplicity versus functionality? Is more better?*

Three different case studies were carried out in different courses at the University of Twente in which group-based learning was applied, and in which different combinations of 12 known problems with planning, operationalisation, and monitoring (left column, Table 1) had been signalled. The problem inventory had already been compiled from available evaluation reports and literature on group-based learning (Barrows, 1997; Bremen & Carleer, 1996; Collis, Anderach, & Van Diepen, 1997; Delhoofen, 1996; Hiltz, 1998; Peters

Table 1. Problems in Planning, Operationalisation and Monitoring in Group-Based Learning.

Problem	Case 1: Multimedia Design Teams	Case 2: International Tele-Teams	Case 3: Management Science Teams
1 Groups do not have a clear picture of what is expected of them.	✓		✓
2 Groups have problems with planning and procrastination.		✓	
3 Groups have problems with organising work between meetings.	✓	✓	✓
4 Groups have problems with access to deliverables and comments.	✓	✓	✓
5 Group members do not take a fair share of the work.	✓	✓	✓
6 Instructors lack overview of the progress of groups.	✓	✓	✓
7 Different instructors treat groups in different ways.	✓		
8 Instructors have difficulties to continue their work at a distance.	✓	✓	
9 Students have limited awareness of other group members.		✓	
10 Conflicts arise due to poor communication.		✓	
11 Students do not start using telematic support tools.		✓	
12 Groups have to wait too long for instructor and peer comments.	✓		

Table 2. Networked Support Options Applied in Study Settings.

Network support option		Case 1: Multimedia Design Teams	Case 2: International Tele-Teams	Case 3: Management Science Teams
1	Web-based planning table	✓	✓	
2	Web-based group archive		✓	✓
3	Workflow	✓	✓	
4	Discussion platform		✓	
5	Video conferencing		✓	
6	Tailor-made Web application			✓

& Powel, 1999; Ronteltap & Eurelings, 1998; Smit & Van Riemsdijk, 1998; Verdejo & Barros, 1999; Van Woerden, 1997).

Six applications based on network technology were selected (in 1996) as candidate solutions which could potentially address one or more of these process-related problems. In each case study a set of different combinations of network support features was trialed (Table 2) in order to learn more about the appropriateness of the supplied network support and instructional remedies in real-life settings, and about the key factors in their success or failure.

RESEARCH STRATEGY

A case-study research strategy (Yin, 1994) was applied in the three case studies. The case studies involved different cohorts of students, for each case, across three successive years. Some student characteristics changed over the years, for example, the computer literacy of students entering the university improved in general over the years. Data triangulation, combining qualitative and quantitative data, was applied to improve the internal validity of the case study findings (Bowen, 1996; Stake, 1995). Evaluation methods used included student questionnaires, instructor and student interviews, panel discussions, observations, server-log analysis, task analysis, and expert reviews (Van der Veen, 2001). The case-study settings and the main lessons learned from each case study are summarised below in the following three sections.

Case Study 1: Multimedia Design Teams (1996–1999)
The setting for the first case study, ''Multimedia Design Teams'', was a course wherein groups of students worked together in teams on an assignment

Fig. 1. Workflow task list as seen by the instructors (http://www.opentext.com/livelink).

involving the design and production of multimedia products. Both students
and instructors were supported by simple HTML Web-based planning tables
throughout this case study (Collis & Gervedink Nijhuis, 2000). The planning
tables contained task and status information and links to group products.
During the second year of the investigation (1997–1998) a more sophisticated
network solution was introduced, involving a workflow application which
automated the flow of information and generated personalised task lists (Fig. 1)
and status overviews. Which of these two (low-end or high-end solution,
simplicity vs. functionality) was more successful?

One conclusion was that the Web-based planning table was easy to
implement. Other advantages included the fact that the task list was easy to
read, making it a good format for communicating information on tasks, status,
and deadlines. Furthermore it provided a facility to link group deliverables
and instructor comments and make them accessible via the Web. The main
disadvantages were that separate tables had to be maintained for each group,
and instructor comments had to be linked one at the time. At first this was done
by instructors and teaching assistants and only after approval of the group
product. This instructional decision was taken to prevent students from
publishing poor results on the public Web. However, the rule also introduced
delays in terms of access to these products for fellow group members and it
was eventually dropped. Appreciation of the Web-based planning table rose
when (a) the groups were made responsible for linking their own deliverables
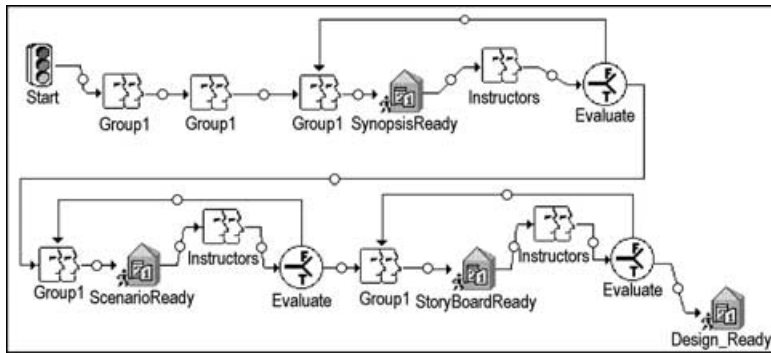to the table (change in locus of control), and (b) the deliverables were

Fig. 2. Workflow of the design phase showing three feedback loops.

immediately linked at the time of submission and no longer only after approval
had been granted (timeliness of information). This resulted not only in flexible
access (via the Web) but also in shortened throughput time. The percentage of
students appreciating this type of network-support option rose from 20% in the
first year to 56% in the last year.

In contrast to the simple, low-end Web-based table, the main advantages of
the high-functionality workflow solution observed in this case were improved
overview of team tasks (Fig. 2) and task status, and instantaneous access to
deliverables and feedback. The management of information by the workflow
tool was more efficient and less error prone than the Web-based planning
tables. The main disadvantages were the lack of adaptability of (current)
workflow tools (Horn & Jablonski, 1998; Sheth, 1997); dependence on
workflow experts; and the rather steep learning curve associated with the
introduction of the workflow paradigm.

In the instructional approach chosen, only the student managers and some
of the instructors used the workflow. The subgroup who used the workflow
tool reported positive experiences in the first investigation. Some problems
(e.g., deadlocks caused by instructor delays) were addressed in a second trial
with a redesigned workflow but at the cost of increasing the complexity of the
workflows. The resulting (very complex) workflows were more difficult to
comprehend and were then abandoned by some of the users.

As a general conclusion to the first case study, the overall success of the
Web-based planning table, compared to the partial success of the workflow
solution, suggests that for network support ''more is not necessarily better''

(Moonen, 1994). The simple solution was more successful than the complex one, despite the fact that the complex solution offered rich and relevant functionality. This reflects other research results in a variety of other technology-support contexts (e.g., see Chapter 4 in Collis & Moonen, 2001). Furthermore the students highly appreciated the simultaneous introduction of briefing and debriefing as part of their group sessions. This confirms the need to pay attention to non-technology improvements as well as network options. Adding technology into the equation is not a substitute for instructional design and we cannot expect technology to offer a 'fix' to inherent problems in the core process.

Case Study 2: International Tele-Teams (1996–1999)
The setting for this case study was a course wherein 14 groups of Dutch students co-operated with 14 groups of Finnish students on a project related to applications of information technology (Van der Veen, Kallio, Pitkånen, & Van Diepen, 1999). The setting therefore involved distance learning and collaboration between virtual teams, with the additional complication that the collaboration spanned national boundaries. Furthermore the teams never met face-to-face.

The starting point of the case study in terms of problems related to planning and operationalisation was the observation that the teams had problems in their work due to a lack of communication. This lack of communication resulted in delays, limited awareness, misunderstandings relating to the foreign students' backgrounds and obligations, and dissatisfaction about the contributions of the foreign team members. It had been found that the intended international collaboration did not occur in practise, as students tended to focus on their local team members for the work on the project. The instructors signalled these problems and expressed the need to monitor progress better so that they would receive early signals if the international teamwork did not work well. A series of networked support options were trialed to see if any of them could provide solutions to improve progress monitoring and facilitate communication among the distributed teams. The groups had to deliver a jointly produced Web site containing information on an information-technology topic. In this site, each group had to give their group's vision on the topic and on what future developments they expected. The assignments were relatively unstructured and it was left to each group to elaborate their work plan. For their communication the students used video conferencing, chat, and e-mail. Two facilities for information sharing were tested out: first,

Assignments	Days	Start		End		Person
First layout homepage	0,750	31-03-99	8:00	31-03-99	15:00	Arjan Berndsen & Maarten Rozie
First planning	0,375	31-03-99	8:00	31-03-99	11:00	Ewout Gerritsma & Ian Kennedy
Introduction story	0,125	31-03-99	8:00	31-03-99	9:00	Finnish group
DELIVERY orientation phase	0,500	31-03-99	8:00	31-03-99	12:00	Dutch group
Information search	0,500	07-04-99	8:00	07-04-99	12:00	Both groups
Working college & information search	0,500	07-04-99	8:00	07-04-99	12:00	Dutch group
DELIVERY working list	1,000	09-04-99	8:00	09-04-99	17:00	Dutch group
Information search	0,500	09-04-99	8:00	09-04-99	12:00	Dutch group
Information processing & personal part	0,500	14-04-99	8:00	14-04-99	12:00	Both groups
Information processing & personal part	0,375	16-04-99	8:00	16-04-99	11:00	Both groups
Evaluation of aspects from the subject (chat)	0,125	16-04-99	8:00	16-04-99	9:00	Both groups
Extra time	0,500	21-04-99	8:00	21-04-99	12:00	
Writing general parts of the report	0,500	23-04-99	8:00	23-04-99	12:00	Both groups
Putting report into HTML	0,500	28-04-99	8:00	28-04-99	12:00	Both groups
Ultimate delivery date of the project	1,000	30-04-99	8:00	30-04-99	17:00	Both groups
Presentation of the project	1,000	07-05-99	8:00	07-05-99	17:00	Ewout Gerritsma & Maarten Rozie

Fig. 3. Web-based planning table showing a group planning.

newsgroups were set up, and later these were replaced by Web-based group archives. A discussion platform was offered for students to raise questions and get answers from their peers. Workflow was introduced to help instructors keep track of the progress of the groups. With so many different network support options available the question that arose was: What will be the optimal balance between simplicity and functionality of network support in order to enable international "tele-teams" to work together successfully even if the students have never met?

A Web-based planning table was used to publish the work plan produced by each group (Fig. 3). This table contained the group's planning with tasks to be fulfilled. Some groups added information about assignment of tasks to individuals, and estimates about the expected workload of each task. No deliverables or status information were published via this table.

The Web-based group archives (both the applications *BSCW* and *Livelink* were used) supported groups successfully in their operationalisation needs with respect to information sharing. Students made little use of the news-groups and Web-based discussion platforms that were provided. Reasons cited included the lack of privacy, more natural ways to find answers to questions locally, and the preference of students to rely on e-mail for asynchronous

communication. For them, e-mail was a network support option that they already knew how to use, and they expected that recipients would check their mailboxes regularly for new messages. This is an interesting example of what we may call the 'inertia effect'; users who already have a well-known tool with which they are reasonably satisfied will be resistant to take up a substitute unless they perceive some immediate and substantial added value or other benefit.

Workflow was introduced in the 1997–1998 cycle of this case study and supported all locations as it was integrated via the Web site of the course. However, the planned-for monitoring of group progress via workflow did not work well, as only a few deadlines were predefined, resulting in limited opportunities for the workflow application to compare progress of tasks with the predefined plan. Therefore, it was concluded that workflow did not offer much added value for projects like these with little prestructuredness. Furthermore, it became obvious that in a distributed setting technical expertise in workflow should be available at each location (Van der Veen, Jones, & Collis, 2000).

In this case study video conferencing sessions were scheduled for the international tele-teams. Given that the distributed groups never actually met face-to-face, the first video conferencing session was designed to be a focus point for getting to know each other. The second session was used for updating each other on progress, and for planning the last part of the project. As the (then currently available) video conferencing over Internet was of poor quality and unable to guarantee uninterrupted connection, ISDN lines were used in combination with dedicated video-conferencing equipment to provide high-quality video and audio. Even so, the evaluation showed that the students' appreciation scores for chat were higher than those for video conferencing in terms of their operationalisation tasks. The chat option offered lower-quality communication but was more accessible for the students who could use this tool whenever they wanted, although obviously it required the synchronous availability of the foreign students.

In the trade off between simplicity and functionality, simplicity in the network support (chat, e-mail, Web-based archive, and table) proved in this case study to be more valuable for the distributed teams than the high-end functionality (video conferencing and workflow). However, this conclusion must be qualified in the light of some instructional decisions made for the course. As only a few deadlines were set, in hindsight we can see that workflow was not a good choice for this setting. Furthermore an instructional

decision was made to not prepare the (Dutch) students for the video conferencing sessions, and this decision influenced the way this support option was used.

Our general conclusion from Case Study 2 is that network support can alleviate many of the problems related to planning, operationalisation, and monitoring of group-based learning. However, in a setting with distributed groups, especially of differing skills levels, motivations, and backgrounds, problems in the collaboration between the remote groups can easily arise due to lack of awareness. These kinds of social-interaction factors should not be underestimated. In this experience these human problems were not solved by the network means applied.

Case Study 3: Management Science Teams (1997–2000)

In the ''Management Science Teams'' case study groups of students worked together on theoretical work and practical case-study assignments (Van der Veen, Van Riemsdijk, Jones, & Collis, 2000). Web support was used to help groups in planning, operationalisating, and monitoring problems during their work on theory and case-study assignments, and for information-sharing purposes. A tailor-made Web application was designed to meet the specific needs of the course (Fig. 4). Is a tailor-made Web application that combines back-end functionality and front-end simplicity preferable to either a low-end solution (Web-based table or archive) or a high-end solution (workflow)? Or again, are the instructional decisions the major factor in the overall group results?

The tailor-made Web application collected group contributions with respect to a set of 24 theory articles that each group had divided for individuals or pairs of students to read. By storing these contributions (originally consisting of sets of questions and answers) in a database, the students could both access their own group's work and also the work of other groups. However, they had access to the latter only after having received approval for their own group's work. Initially the groups were required to rank the contributions of other groups. Workflow concepts such as task lists, progress monitoring, and automation of (conditional) flow of information were integrated into the tailor-made network application that merely referred to the concepts of student and instructor tasks. Thus, minimal learning effort was required of students. The evaluation showed however that the students had low appreciation of the tasks supported by the network tool, resulting in limited use of the tailor-made Web application in that year (1998–1999) and resulting in

Fig. 4. Screen offering conditional access to excellent summaries of other groups.

changes to the instructional design (Van der Veen, Van Riemsdijk, Slabbekoorn, & Van de Kamp, 1999).

In the last year of this case study (1999–2000) the task of submitting questions and answers was replaced by submitting summaries of the theory articles and optional reading of excellent summaries. In contrast to the previous year these tasks were now highly appreciated by students as more relevant, and the server log showed that extensive use was now made of the network support offered (Van der Veen et al., 2000). The observation here is that the technology support was rejected when the tasks it supported were not seen as helpful by students, but when the instructional design was improved the students used the tool support enthusiastically. Clearly, instructionally appropriate designs are critical to success.

In order to support the groups in the operationalisation of their plans, support for file sharing between meetings was offered. In the 1998–1999 cycle of the case study, the groupware product *BSCW* was used to implement group archives but only a minority of the groups used this support. A much simpler solution (a Web-based file-upload facility with only one directory) was used in the following year (1999–2000) and this solution was used by the majority of the groups offered (Van der Veen et al., 2000). It is clear that for the successful use of network support for applications such as file sharing, uptake by all group members is essential (Dix, Finlay, Abowd, & Beale, 1998). We conclude that in such circumstances if there is a clear trade-off between functionality and simplicity the latter should prevail. However, the ideal of combining rich functionality with simplicity of concepts and use within a generic solution would be a desirable alternative, compared to having to choose between simplicity and functionality.

As a general conclusion from Case Study 3, it has been shown that network support can combine the key functionalities of a high-end solution but presented via an interface that is simple to use and conceptually tailored to the instructional task. A precondition for take-up is that the tasks should be perceived as relevant by the users. However, a tailor-made solution has the disadvantages of requiring local (and potentially costly) programming work and lack of generalisability to other settings.

SOLVING PROBLEMS (OR NOT)

Twelve key problems in planning, operationalising, and monitoring which were synthesised from evaluation reports and literature were first presented in Table 1. These are repeated here in the left hand column of Table 3 where they are tabulated according to the key results of the three case studies in order to show to what extent the problems were solved at the end of the investigations. Table 3 shows that in particular many practical aspects of the original set of problems have been solved by means of the network support combinations used. The results show that three of the original 12 problems are dwindling in impact (Items 4, 8, and 11, Table 3) due to general increases in access to and use of network support for many aspects of instructors' and students' activities. Others of the original 12 items will remain a problem because of the human element (Items 7, 9, 10, and 12), although network options, if used effectively, can reduce some aspects of the problems. A number of the items

Table 3. Review of Problems With Planning, Operationalisation, and Monitoring and the Progress Made.

Problem	Findings and progress made
1. Groups do not have a clear picture of what is expected of them.	Tasks can be communicated via a Web-based planning table, workflow activity diagrams and task lists (Case 1), or via a tailor-made application (Case 3).
2. Groups have problems with planning and procrastination.	Despite delays due to lack of communication and use of asynchronous communication, groups met the final deadline (Case 2).
3. Groups have problems with organising work between meetings.	Information sharing can be arranged via Web-based group archives, workflow, e-mail or a tailor-made application (Cases 1, 2, 3). Students focused on working with their local group members (Case 2).
4. Groups have problems with access to deliverables and comments.	Web-based tables were used to link deliverables and comments, but with some delay (because of an instructional decision). Workflow solved this problem for those using it, but Web-based tables also addressed this problem once the instructional decision relating to control of the table was changed (Case 1). Web-based group archives arranged access except for final products for which access to server directories was needed (Case 2). Groups used Web-based group archives, e-mail and a tailor-made application for information sharing (Case 3).
5. Group members do not take a fair share of the work.	No network support was used to address this problem, but there was an improved appreciation of task division when groups divided their tasks themselves (Case 1). Differences in motivation and skills resulted in differences in contributions by group members, regardless of the network support involved (Case 2). Most students were satisfied with the task division in their groups and the tailor-made Web application supported monitoring by the groups themselves (Case 3).
6. Instructors lack overview of the progress of groups.	The Web-based table and workflow reduced logistical problems. There was a more-efficient progress overview with workflow (Case 1).

Table 3. (*continued*).

Problem	Findings and progress made
	Instructors had a good overview of the local subgroups but a limited overview of international co-operation. Network support was exploited for this overview (Case 2). A progress overview of reading tasks was enabled but hardly used by the instructors (Case 3).
7. Different instructors treat groups in different ways.	Task specialisation and visibility of all instructor feedback in both the Web-based table and workflow helped prevent inconsistencies (Case 1).
8. Instructors have difficulties to continue their work at a distance.	Workflow allowed both reading and writing at a distance for those parts of the course site controlled by the workflow. Web-based tables allowed only reading from a distance (Case 1). Instructor contacts occurred mostly before and after each course. During the course the instructors concentrated on coaching their local students in a face-to-face manner (Case 2).
9. Students have limited awareness of other group members.	Differences among the students were hard to appreciate at a distance. Video conferencing helped the student to get to know each other but during their on-going work, students focused on their local peers (Case 2).
10. Conflicts arise due to poor communication.	In some groups there was irritation as a result of limited awareness, lack of motivation or poor performance among the local and remote group members. Network support did not seem to reduce this (Case 2).
11. Students do not start using network-support tools.	Mostly specialists used workflow. Some users abandoned the workflows (Case 1). Discussion platforms were not used as students relied on local expertise (Case 2). Network support was used only when the students appreciated the tasks (Case 3).
12. Groups have to wait too long for instructor and peer comments.	Errors and logistical delays occurred in early uses of Web-based tables but were reduced during the workflow use and subsequently also to some extent with the Web-based table. Delays related to instructor load remained (Case 1).

represent a synergy between instructional decisions and tool characteristics (Items 1, 2, 3, 5, and 6), where the tool itself will have marginal impact on its own. The decisions of instructors and groups regarding the use of the tool will dominate the impact of the tool on the problem. For example, if an instructor is not explicit in his or her specification of what is expected of groups, a planning tool cannot in itself remedy the vagueness. However, network support tools can help the students to identify where they need clarification, and can stimulate the instructor to specify his or her expectations in a more-operational way or help groups define their own plans which can then be commented upon by instructors or peers.

Looking at the questions in terms of the passage of time between their formulation in 1996 and the completion of this research in 2001, it can be said in summary that most of the 12 identified problems remain, but that solutions can be offered in terms of the combination of instructional decisions, network tools, and the effective use of those tools. An additional problem was also discovered: "Groups whose members have different motivation, skills, and backgrounds and who primarily interact via network means may have on-going problems with planning and monitoring" (Van der Veen, 2001, p. 258). This could be seen as an extension of Items 9 and 10 (Table 3) but focused on aspects of human interaction.

Instructional Remedies and Network Support

Can we isolate what made the major difference when trying to solve the problems in planning, operationalisation, and monitoring? Was it adaptations in the instructional strategy or was it the introduction of new or additional network support, or a combination of both, which relieved the problems of instructors and students? In this section the interactions between network support and instructional remedies are discussed.

The instructional methods applied in the case studies showed many variations, not only across the different courses providing the case-study settings but also within a single case study setting over time (three successive years for each case study). Some of the instructional decisions which were found to most affect the planning, operationalisation, and monitoring problems of the students and instructors were

Task relevance – The "Management Science Teams" case study showed that tasks which are not perceived as very helpful will be abandoned (if this is permitted), whatever network support is being used. After changing the

instructional design of the tasks this was remedied and the network-supported tasks were carried out as planned.

Control – The "locus of control" with respect to the network support should be considered. The Web-based planning table was intended to serve the groups with respect to their tasks and progress, but was initially controlled by the instructors ("Multimedia Design Teams"). When ownership was transferred to the groups, they took over maintenance of the tables and better addressed their operationalisation and monitoring needs with the contribution of this network support option.

Level of motivation – The students' level of motivation in the "International Tele-Teams" case study varied depending on whether the projects were an obligatory part of their course. If the activities are obligatory and if they contribute to assessment then student use of any network tool is more likely to increase.

Task formulation – The level of detail in which tasks are prescribed should be considered carefully. Giving clear details about how tasks are to be carried out and making these easy to reference via a network tool can make task execution more efficient for the groups, but at the same time limits the opportunities for groups to define their own way of working. On the other hand, giving few details about how to work and what to do if collaboration does not work well may lead to situations in which dysfunctioning of groups is discovered late and is hard to remedy. Network tools can help instructors to remember to specify details in a consistent and timely way, but cannot force the instructor to meet this expectation.

The above examples make it clear that instructional remedies and network support solutions are interrelated. However, sound instructional design is primary. After that network support can enable activities and make tasks easier if the right balance between simplicity of use and functionality is achieved. The balance between functionality choices and simplicity to learn and use then becomes a major issue.

DISCUSSION: BEST OF BOTH WORLDS!

Given (a) the problems in planning, operationalisation, and monitoring, (b) the appropriate instructional remedies and (c) network support options that may help, how is a best fit determined? Based on the analysis of the case-study

outcomes, a selection of important factors in decisions relating to network support and instructional design is given followed by a discussion of future developments.

A number of key factors which should be taken into account when mapping solutions onto problems that have been identified. The level of computer literacy of the user (the student or instructor) should be taken into consideration when selecting network support options. The potential benefits of working with distant group members and of using network support options should be clear to the students to ensure serious uptake of the planned tasks and the tools provided to support the tasks. The instructor should consider the prestructuredness of the group-based learning tasks, which should fit both with the level of knowledge and experience of the students and with the network support options used. When groups of learners in two or more locations work together as a team, the groups at the different locations should be of similar size, otherwise there is a risk that one subgroup takes control and ignores the other subgroups when making plans and decisions.

Designing group tasks to be interrelated can help ensure real collaboration takes place; otherwise groups may split up the tasks to a large extent and work separately. The relevance of the tasks in relation to the course and its assessment should be clear to the students. When considering tailor-made solutions, the cost of building and maintaining the application should be taken into consideration. This relates to the economies-of-scale issue which makes certain solutions worth considering depending on the numbers of instructors and students that can potentially benefit. Whereas some solutions are only feasible with sufficient users, other solutions may not be scalable to large numbers of users due to the human administrative and technical effort required, the errors that may occur, and the scarcity of dedicated equipment (e.g., dedicated video conferencing equipment).

A major finding of the research is the desirability of combining the functionality of high-end options with simplicity of use for the user. This position was reached following the end of the third case study at the point of evaluating the tailor-made solution. The evaluation showed that workflow mechanisms used in a simple and transparent way were found to be helpful by users. This leads to the conclusion that if the functionality of workflow can be exploited without burdening the users with learning difficult concepts and tools, then maybe we can combine simplicity (of services as perceived by the user, of learning, and of use) with rich underlying

functionality. In this case study course-specific aspects had been hard-wired into the tailor-made (prototype) application. However, apart from not being generic, tailor-made solutions can be costly (in terms of time and effort) to develop and maintain and the results are unlikely to be scalable. The ideal approach then would seem to be a generic solution, for example, by the transparent integration of workflow functionality into a generic e-learning environment.

The most important development since the start of this research in 1996 has been the fact that Web-based course-management systems have emerged and have reached a level of maturity where they are being introduced into higher education in The Netherlands and elsewhere on a large scale. A major step forward in addressing the simplicity-functionality dilemma is therefore now possible with certain Web-based course-management systems (Droste, 2000). These systems are continually undergoing development and many of them now offer features such as group archives, discussion platforms, chat, and other features that have been found to be particularly useful in group-based learning (Landon, 2000). Of these systems, the instructors and group learners will favour those which best manage to combine rich and appropriate functionality with simple, natural interface modalities. If Web-based course-management systems are designed to offer instructors and also students control over many aspects of functionality in a simple-to-use way within an integrated environment available via a Web browser, then simplicity and high-end functionalities, as well as user control, can be arranged in a generic way via the same Web-based course-management system. The TeleTOP system developed in the Faculty of Educational Science and Technology of the University of Twente and now used in more than 600 courses throughout the university as well as in other institutions is one example of such an approach (Collis & Moonen, 2001; Tielemans & Collis, 1999). So the combination of enhanced e-learning environments with the rich resources of the Web such as the emerging digital libraries (Fox, 2000) offers a solution now to the simplicity-versus-functionality dilemma.

Further research should follow from the recommendations given above with the goal of extending our understanding of the success factors concerning optimal support for group learners and instructors, bearing in mind the requirement for minimal learning effort in relation to the supporting technology. Settings in which all group members are distributed (i.e., maximal distribution, with a single learner in each location) require special attention as this situation will arise more frequently in the future. Consequently

instructors of distance learning courses are eager to know to what extent and under what circumstances they can apply group-based learning formats.

To look further into the future, we expect that many technological developments will alter the future scenario. The new generation of high performance networks will enable applications such as high-quality video conferencing at the desktop (Lan & Gemmill, 2000). Developments in interface technologies bring the promise of natural communication modalities based on speech and vision, with intelligent agents and intelligent spaces assisting the user in his or her tasks. Developments in virtual reality and augmented reality will alter the user's experience of interaction with both real and cyber worlds (which will increasingly merge). At the same time the combination of mobile devices and wireless connectivity offers the prospect of flexible access to a wide variety of these (and future) learning services and resources. The future of technology allows us to develop a vision of ubiquitous learning supported by advanced learning environments which support learners anytime, anywhere using intuitive interaction modalities and giving access to a world of functionality, resources, and services.

These and other developments in both technology and pedagogy can be expected to impact group-based learning and the problems which were identified in planning, operationalisation, and monitoring in group-based learning. This research has been an attempt to contribute to these new developments. The experiments with network support tools in live learning settings has provided insights into some success factors for network support in education, and has identified some of the instructional and human-factors issues which will remain influential factors affecting the future design and successful deployment of learning settings supported by network applications.

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