# TELEMATICS FOR GROUP-BASED LEARNING: SIMPLICITY VERSUS (OR WITH?) FUNCTIONALITY.

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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 telematic 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 planning, operationalisation and monitoring in group-based learning in higher education and the identification of telematic 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.*

## 1. Introduction

In the research project described here the potential of a number of telematic options to support group-based learning was investigated, in particular with respect to solving problems in planning, operationalisation and monitoring tasks [22]. 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 case are presented. We asked: which of the problems in planning, operationalisation and monitoring were solved? Was it the telematic support or the instructional design that made the difference, or is the solution to be sought in a combination of the two? What

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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 project continually arises: *When selecting a telematic support option, is the key choice that of simplicity versus functionality*

Three different case studies were carried out in the setting of 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 (*Table 1*) had been signalled. The problem inventory had already been compiled from available evaluation reports and literature on group-based learning [1] [3] [4] [7] [11] [16] [17] [19] [25] [28] [29].

**Table 1. Problems in planning, operationalisation and monitoring in group-based learning**

| Problem | | Multimedia Design Teams | International Tele-Teams | 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. | ☐ | | |

Six telematic support options 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 telematic support features was trialled (*Table 2*) in order to learn more about the appropriateness of the supplied telematic support and instructional remedies in real-life settings, and about the key factors in their success or failure.

**Table 2. Telematic support options applied in case study settings**

| Telematic support option | Multimedia Design Teams | International Tele-Teams | 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 | | | | |

## 2. Research strategy

A case study research strategy [30] was applied in the three case studies (Sections 3-5). The case studies involved different cohorts of students across successive years, and 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 [2] [20]. Evaluation methods used included student questionnaires, instructor and student interviews, panel discussions, observations, server log analysis, task analysis and expert reviews [22]. The case study settings and the main lessons learned from each case study are summarised below in Sections 3-5.

## 3. 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 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 [5]. The planning tables contained task and status information and links to group products. During the second year of the investigation (1997-98) a more sophisticated solution was introduced, involving a workflow application which automated the flow of information and generated personalised task lists (*Figure 1*) and status overviews. *Which of these two (low-end or high-end solution, simplicity versus functionality) was more successful?*

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

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 makes them accessible via the Web. The main disadvantages were that separate tables had to be maintained for each group and each group product and instructor comment 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 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 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 telematic 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 (*Figure 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 [12] [18], dependence on workflow experts and the rather steep learning curve associated with the introduction of the workflow paradigm.

**Figure 2. Workflow of the design phase showing three feedback loops.**

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 (for example 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 telematic support *"more is not necessarily better"*. 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 [6] [15]. 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 telematic 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.

## 4. Case Study 2: International Tele-Teams (1996-1999)

The setting for this case study was a course wherein fourteen groups of Dutch students cooperated with fourteen groups of Finnish students on a project related to applications of information technology [24]. 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 and 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 telematic support options were trialled to see if ICT solutions could improve progress monitoring and facilitate communication between 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 newsgroups were set up, 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 telematic support options available the question that arises is: *What will be the optimal balance between simplicity and functionality of telematic 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 (*Figure 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 was published via this table.

**Figure 3. Web-based planning table showing a group planning.**

The *Web-based group archives* (both BSCW and Livelink were used) supported groups successfully in their operationalisation needs with respect to information sharing. Students made little use of the newsgroups 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 telematic support option that they already knew how to use, and they expected that recipients would check their mailbox 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 of a substitute unless they perceive some immediate added value or other benefit.

*Workflow* was introduced in the 1997-98 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 [23].
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. In the event, 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 synchronous availability of the foreign students.

In the trade off between simplicity and functionality, simplicity in the telematic 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 telematic 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, motivation and background, 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 problems were not solved by the telematic means applied.*

## 5. 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 [26]. Web support was used to help groups in planning, operationalisation, 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 (*Figure 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?*

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

The tailor-made Web application collected group contributions with respect to a set of 24 theory articles which 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 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 e-learning application, which 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 telematic tool, resulting in limited use of the tailor-made Web application in that year (1998-99) and resulting in changes to the instructional design [27].

In the last year of this case study (1999-2000) the task of submitting questions and answers were 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 telematic support offered [26]. 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.

In order to support the groups in the *operationalisation* of their plans, support for file sharing between meetings was offered. In the 1998-99 cycle of the case study, 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 [26]. It is clear that for the successful use of telematic support for applications such as file sharing, uptake by all group members is essential [8]. 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 *telematic 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 pre-condition 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.

## 6. Solving problems (or not)

The twelve problems in planning, operationalisation 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 telematic 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 telematic 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 telematic options, if used effectively, can reduce some aspects of the problems. A number of the items represent a synergy between instructional decisions and tool characteristics (Items 1, 2, 3, 5 and 6), where the tool 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, telematic 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 twelve identified problems remain, but that solutions can be offered in terms of the combination of instructional decisions, telematic tools and the effective use of those tools. An additional problem has been discovered: "Groups whose members have different motivation, skills, and backgrounds and who primarily interact via telematic means may have on-going problems with planning and monitoring". This could be seen as an extension of Items 9 and 10 (*Table 3*) but focused on aspects of human interaction.

**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).<br>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).<br>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).<br>Web-based group archives arranged access except for final products for which access to server directories was needed (Case 2).<br>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 telematic support 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 telematic support involved (Case 2).<br>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).<br>Instructors had a good overview of the local subgroups but a limited overview of international cooperation. Telematic support was exploited for this overview (Case 2). 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).<br>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. Telematic support did not seem to reduce this (Case 2). |
| 11. Students do not start using telematic support tools. | Mostly specialists used workflow. Some users abandoned the workflows (Case 1).<br>Discussion platforms were not used as students relied on local expertise (Case 2).<br>Telematic 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.<br>Delays related to instructor load remained (Case 1). |

## 7. Instructional remedies and telematic 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 telematic support, or a combination of both, which relieved the problems of instructors and students? In this section the interactions between telematic 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 telematic support is being used. After changing the instructional design of the tasks this was remedied and the telematic-supported tasks were carried out as planned.

*Control* - The "locus of control" with respect to the telematic support should be considered. The Web-based planning table was supposed 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 table and better addressed their operationalisation and monitoring needs with the contribution of this telematic 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 telematic 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 telematic 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. Telematic 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 telematic support solutions are interrelated. *However, sound instructional design is primary. After that telematic 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.

## 8. Discussion: Best of both worlds!

Given (a) the problems in planning, operationalisation and monitoring, (b) the appropriate instructional remedies and (c) telematic 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 telematic 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 have been identified. The level of computer literacy of the user (the student or instructor) should be taken into consideration when selecting telematic support options. The potential benefits of working with distant group members and of using telematic 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 telematic 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 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 hardwired into the tailor-made (prototype) application. 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 is 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 is 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 [9]. 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 [14]. 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 400 courses throughout the university is one example of such an approach [21]. So the combination of enhanced e-learning environments with the rich resources of the Web such as the emerging digital libraries [10] 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 (that is, 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 [13]. 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 radically alter the user's experience of interaction with both the real and the cyber worlds (which will increasing merge in our experience). At the same time the combination of mobile devices and wireless connectivity offers the prospect of ubiquitous access to all 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 rich 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 telematic support tools in live learning settings has provided insights into some success factors for telematic 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 telematics.

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