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Implementing ICT in education faculty wide

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At the end of 1999 the faculty of Technology, Policy and Management (TPM) of Delft University of Technology in The Netherlands decided to implement ICT in education throughout the faculty. Since September 2000, all courses are taught using an electronic learning environment (ELE). The implementation process is described in this article.

The starting point for the implementation lies within university-wide activities. In September 1999 Blackboard CourseInfo was made available for all teachers and faculties of Delft University of Technology. The faculty of TPM decided to use this platform as a basis for a faculty wide implementation of ICT in Education.

The TPM implementation plan consists of three lines of activities. The first line of activities is technology oriented. The aim of this first line is to create smooth connections between the different computer systems and data that are used in the educational processes.

The second line of activities is aimed at creating and using a web-site in Blackboard for each course taught. These web-sites contain at least detailed descriptions of the course and course materials. Furthermore, an introductory course for teachers on how to use the Blackboard system and providing technical support is included in this line of activities.

The third line of activities is geared towards developing new learning environments for courses. One of the projects within this line of activities is to support a number of teachers in developing and using new teaching methods, based upon possibilities offered by these new technologies. As of June 2000 five teachers have re-designed their courses, have taught their course in the new format and have evaluated this.

1. Introduction

The TPM faculty has a wide range of educational products: a full-time course in Systems Engineering, Policy Analysis and Management (SEPA), a part-time SEPA course, an MSc SEPA course for international students, interfaculty courses, the UNITECH exchange programme and the Postgraduate School for Teacher Education.

Ma et al. (2000) list measures of success to indicate whether virtual education systems have been beneficial. These measures relate to students and teachers as well as to administrators. With respect to students, the types of benefit include time savings (e.g. less

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travel time), information availability (access anytime and anyplace) and scheduling flexibility. This suggests that types of education such as international education, part-time and dual training are types of education which are especially suitable for ICT-oriented training. Therefore, the TPM faculty has given ICT a central role in its education.

1.1 Phases of growing interest

The growing interest in ICT in education at the faculty can be divided into three phases.

Phase 1

The first phase started around 1998 due to student dissatisfaction regarding the number of computers available for doing their homework and for using various practical training applications. A working group, consisting of students, teachers and educational consultants, developed ideas and made recommendations to management. This phase is characterised by its 'bottom-up' initiative.

Phase 2

During the second phase, from 1999 onwards, those ideas were organised into three development lines, namely:

1st supplying information to students and teachers with the help of ICT, e.g. a student Gateway,

2nd supporting the educational programme with the help of an electronic learning environment,

3rd applying innovative didactical methods with the aid of computers.

The faculty's management facilitated the activities within these three lines to a limited degree. Because of the growing interest in ICT in education, a small faculty delegation undertook a field trip to a number of prominent US universities: Indiana State University in Bloomington, Carnegie Mellon in Pittsburg, George Mason University in Washington, Georgia Institute of Technology and Georgia State University in Atlanta. Research into the development of ICT in education at these universities, has resulted in the faculty's agenda for ICT in education.

This agenda is based on 3 premises:

- students should be regarded as knowledge and information intensive workers and should be facilitated accordingly,

- a standard Electronic Learning Environment (ELE) is essential for both students and teachers,
- in an ICT-rich environment, educational renewal and improvement are a challenge, but not a matter of course.

A number of developments within Delft University of Technology also corresponded well with these three premises. The introduction of a new Grade Administration System (Volg+), a Digital Study Guide, an XML Course Project, and the development of a Student Gateway, all support the idea of viewing students as information intensive workers.

Characteristic features of this second phase were that the faculty stimulated, determined boundaries, and facilitated to a limited degree.

Phase 3

The result of this was that in phase three a project plan was drawn up to reinforce the three lines of activity mentioned above, into a completely facilitated project, called *IMAGO*. This plan was approved by the University Board in June 2001 and the faculty has received financial assistance from the board to allow us to implement ICT in education with even more dedication, manpower and means.

1.2 Implementation Strategies

In general, there are four main approaches for implementing innovations: diffusive, directive, interactive and developmental (Zee 1997). The choice of implementation strategy is largely dependent on the nature of the innovation and the organisational context. The diffusive and directive approaches have the advantage that they are explicit processes with a beginning and an end. However, where staff are expected to play a creative role, to be involved, or even are expected to take part in decision making, these approaches are insufficient, and the importance of an interactive and developmental approach to changes increases. In such a case, outlining the final objective is no longer possible, but is replaced by acceptance of and participation in the change. Co-operation with the members of staff involved is essential to success.

The first phase of the implementation process of ICT in education at TPM followed the interactive approach. However, there is a deliberate transition to the developmental approach during the second and third phases.

Both the interactive and the developmental approaches will be discussed below.

The Interactive Approach

The most important aspect of the interactive approach is that people can not just be the implementers of policies devised by others. The basic concept is that people will only feel responsible for their work when they can also influence the process. In this approach, ideas for change coming from above or outside should be initiated in such a way that the people involved are ultimately made responsible for their development, implementation and consolidation within the organisation. In doing so, one has to take into account the fact that the actual implementation may deviate from the original idea. The advantage is that this direction will then certainly be accepted. The problem, rather than the solution, forms the starting point that needs to be tackled with a bottom-up approach.

Management sets the boundaries or marks out the playing field within which the change is to take place. The keywords here are: interaction, bargaining and mutual adjustment.

By using this approach, each process of change will look different. Perseverance and inventiveness are required of the project leader, who will have to put a great deal of energy into building up goodwill and a network of connections. Above all, the project leader must not think that he is able to control the process.

The Developmental Approach

Here again, the starting point of the developmental approach is not the solution, but the problem. Whereas the emphasis is on finding solutions to an existing problem in an interactive change project, the emphasis is on strengthening competences in a developmental change project. The objective here is to create the conditions for self-sustaining development. Developmental change is the interaction between design and accident, of trying over and over, of grasping the initiative and relinquishing it again. The ultimate objective is to increase the staff's competences, and thereby also increasing their problem solving abilities. This is not a process that goes according to plan. The keywords of this process are: challenging, changing key competences, inspiring, becoming the problem owner, maturing and experimenting, an enquiring mind, exchanging knowledge and experience, and improvising. The first three approaches can be said to apply to controlled changes; there is no question of control with this developmental approach, but of stimulating and facilitating.

The diffusive and directive approaches can be described as the classic models for organisational development, where divisions are drawn between thinking = diagnosing and doing = implementing (Wierdsma 1999).

Wierdsma compares these implementation processes to a 'package tour', where the 'destination' is more or less known and is reached via established routes. This is contrary to a 'migration', during which the participants are constantly debating what their destination is and how they are going to get there. Thinking and doing alternate more often. According to Wierdsma, the model of an implementation trajectory designed to increase collective competences should look like a 'migration'.

Ma et al. (2000) suggest a set of critical success factors for virtual education systems. They have reformulated the description of these factors from their original application to executive information systems. Although these critical success factors are related to a system, we will discuss them in relation to the complete project:

- *There should be an executive sponsor* who should be sufficiently committed to the project. The TPM project started as a 'bottom-up' project, but in the third phase the University Board provided additional financial assistance in order to increase the momentum.
- *It is necessary to have an operating sponsor*. Within the faculty, the project leader acts as an operating sponsor.
- *The quality of the staff that supports users is important*. Support was not only provided in terms of technical support, but also included general didactical support and more specific support in the field of ICT in education. In the sections below we will mention the support, which is essential, in some more detail.
- *Appropriate choice of technology* (hardware and software). The choice of the electronic learning platform was made at the university level. However, this platform has proved to be quite easy to work with.
- *Management of data.* The electronic learning platform is used to structure the data and information.
- *Clear link to business objectives.* All the development lines have been set up because of a perceived problem in this area or because it was thought that ICT could provide additional benefits. It was never applied in terms of a technology push.
- *Management of organisational resistance.* As will be mentioned below, possible resistance on the part of the teachers was dealt with by developing appropriate training and using a platform which is easy to work with.

- *Management of the system, evolution and spread*. Communication about ICT in education within the faculty is part of the project, as will also be mentioned below.

The three lines of development the project consists of will be discussed in more detail in the following section.

2. Description of the development lines

2.1 Development Line 1: Providing information to students and teachers using ICT

The following activities are part of this line of development:

- developing a functional link between Blackboard, the grade administration system (Volg+), the examination registration system (TAS), and the Digital Study Guide,
- making student-oriented educational, organisational and administrative information available in such a way that the student can extract the information necessary for his/her study (planning) him/herself,
- making teacher-oriented educational, organisational and administrative information available in such a way that the teacher can find the information he/she needs.

A pilot will be set up with the aid of centralised tools and links, to provide student-oriented information via Blackboard and/or the Internet, thereby recognising the principle that the faculty views its students as information and knowledge intensive workers.

With regard to improving the provision of information to students with information and communication technology, TPM is especially seeking to improve the links with the Digital Study Guide recently started by the Faculty of Civil Engineering and Geosciences at Delft University of Technology and with the Electronic Learning Environment/Student Gateway project of the Department for Technical Support of the university. Efforts are already being made to provide students with as much information as possible via the Web. The faculty's Web-site is now being renovated for this purpose.

Within the next 2 years, the faculty expects the Study Guide to be completely digital, with links to TAS and Volg+, so that:

- administrative student information such as grades are available to the students and teachers via the Internet,
- accurate information concerning courses and organisational aspects can be accessed by students and teachers, e.g. study guide, examination registration system, timetables, course news, etc.

The results are meant for TPM's full-time, part-time and MSc courses, as well as for the interfaculty courses.

The faculty started on parts of this project in June 2000. The faculty Web-site has been improved, and the faculty's intranet has recently become available. Blackboard's course information already utilises the module descriptions of the Digital Study Guide. Completion of this line of development is expected in December 2001, when the Study Guides for the academic year 2002/2003 will be available in digital form.

Various presentations will be held for teachers and students to keep the faculty members informed of progress. During these meetings, results will be presented and discussed. The results will also be presented as interim reports to the project management. A final report of the results will be produced which will be published throughout the university.

2.2 Development line 2: Faculty-wide use of Blackboard

The second line of activities is aimed at creating and using a Web-site in Blackboard for each course taught at the faculty of TPM, which includes the SEPA school and interfaculty teaching for the other faculties of the university. Many of the teachers at the faculty already used the web to publish their slides and course information, but it was not clear to the students where they could find all of the information. Blackboard provides a clear starting point for the students.

Faculty-wide use of Blackboard means that for each course taught at the faculty there is at least one web site containing the following components:

- *announcements* regarding new information on the Web-site and schedule changes,
- *course information* including course descriptions, examination requirements and the course schedule,
- *course documents* containing slides of the lectures, background information, additional information and practice material such as old examinations,
- *assignments* which students have to complete,
- *communication* facilities which can for example used to send e-mail to inform students.

In September 2001, all courses will be using Blackboard with the above specifications. But how did we reach this goal?

A group of four students and some enthusiastic teachers started using Blackboard in the beginning of 2000. In February, they organised a meeting to inform other teachers about

their experiences and the possibilities of Blackboard. During this meeting, three teachers presented their experiences with ICT in Education, and one of the students talked about the use of Blackboard. This resulted in some of the new courses being taught in Blackboard.

In May 2000, the University Board officially announced Blackboard as the electronic learning platform for the next three years. This was the start of the rapidly increasing use of Blackboard by teachers and students. In September 2000, the new fist year students were instructed on how to use Blackboard, but the teachers also had to learn how to use it. The four students therefore developed a two-hour introduction to Blackboard. This introductory course is taught every couple of weeks to a group of not more than twenty faculty members. The faculty members therefore have ample opportunity to attend the introduction.

The course consists of a short introduction to ICT in Education, an explanation of the use of Blackboard, and a number of exercises for the participants. The exercises are essential to the course, because they allow the faculty members to overcome their possible initial fears. There are two main aspects that discourage teachers from using Blackboard:

- *Firstly, they say that it is too difficult for them, and that they don't know anything about HTML.*

  Blackboard has been developed to be used without any prior knowledge of HTML. However, with knowledge of HTML, Blackboard can offer some additional functionality.
- *Secondly, they say that they don't have enough time to use it.*

  It is faster to place a document in Blackboard than it is to place it on a regular Web-site. Only a Web Browser is needed to access Blackboard.

Steel and Hudson (2001), who investigated the perceptions and experiences of educational technology from the perspective of university teachers, found similar fears in their interviews with teachers. They note that an important fear of teachers for using educational technology concerns technological failure and the problems associated with that, whether perceived or lived, imagined or actual. They also indicate that lack of time is one of the most important problems for teachers when implementing educational innovation. University management should recognise that resources need to be made available in terms of staff 'space' to develop such innovation.

At TPM, the introductory course is the teachers' first step towards using Blackboard. After completing the exercises, all the participants are convinced that Blackboard is a good and easy-to-use system for communicating with their students.

The following step is for them to actually use it in one of their courses. An important issue is that there is good and fast support. The teachers receive a lot of information in the introductory course, but are unable to remember it all, especially if they are not very experienced computer users. Therefore, once they start using Blackboard, they have all kinds of questions about it. The four students are available to answer their questions. If a teacher mails the students, they usually react as quickly as possible by mail, or stop by the teacher's office to show him/her how to solve the problem. Altogether the students spend about 15 hours a week supporting the teachers, and a further 5 hours on other activities, such as the introductory course and meetings.

As was mentioned above, support is an essential part of the total implementation. Without this fast support, the faculty members would not be so enthusiastic about Blackboard, nor would they be able to use the system to its full extent.

2.3 Development line 3: Developing learning environments for courses

In January 2000, a two-hour seminar on the use of ICT in education (ICTE) was organised for the teaching staff of TPM. Some TPM teachers demonstrated and discussed good ICTE practices in their courses. An expert on ICT in education also presented the experiences of other users. The seminar ended with an invitation to the participants to take part in the third line of development of the project on ICT in education.

In February 2000, the third line of the TPM project on ICT in education was started. Five TPM teachers were involved in this activity, supported by an educational consultant, two members of the faculty's educational administration unit, and two student assistants. The primary goals of this third line of development were to design and develop an electronic learning environment for each of five courses, and to gain knowledge and expertise in online education. Electronic learning was to be one of the elements of the course, alongside face-to-face activities such as lectures or group meetings. Another aim of this group was to communicate about their results with the rest of the faculty, and to provide the educational staff with practical guidelines as to when and how ICT can be used in their own courses

In Line 3, the individual teachers redesign their own courses. The courses differ in target group (initial full-time students or initial part-time students) and content (Systems Engineering and Policy Analysis or Social Studies). The teachers discussed each other's designs and solutions during group meetings, giving feedback and sharing their expertise. They were supported in this process by the educational consultant, who is an ICTE expert. In

addition, the teaching assistants of Line 2 assisted them by actually creating ELEs in the university's Blackboard system.

The group involved in Line 3 meet on a monthly basis. In between meetings the teachers carry out the main activities which are then discussed again in the group. The activities were scheduled according to the following phases:

1. *Descriptions of current teaching practices.* Amongst other things, these descriptions contain learning goals, educational formats, educational activities of the teacher and learning activities of the students.
2. *Identification of problems and wishes.* The teacher describes the problems that accompany current teaching practices and/or the aspects he/she wishes to change about them. The teacher also pinpoints who is experiencing these problems and determines the cause of the problems.
3. *Choosing a solution.* The teacher searches the Internet or literature for available knowledge or expertise of other teachers who have experienced similar problems. Then a number of possible solutions are identified, and for each solution the shortcomings and gains are analysed. Finally, the best solution is chosen.
4. *Writing an Action Plan.* This plan starts with a description of the new course, especially concerning educational format, and methods and patterns of communication. It also contains a list of new teaching materials, for example educational multimedia applications. The action plan contains a detailed plan for the development of the new course and, where appropriate, the new teaching materials. The first implementation of the new course should also be planned.
5. *Evaluation of the new approach.* The cycle of redesigning the course ends with an evaluation of the results. This evaluation should be carefully planned, which means that a list of the people involved should be available, possibly a number of questionnaires should be developed and filled out by students, also a number of interviews should be held, and an evaluation report should be written.

At the time of writing (July 2001), Line 3 activities have been in progress for a little over one year. One full cycle of design, development, implementation and evaluation has been carried out for five courses. The following five courses were involved in the first cycle:

1. Quantitative Dynamic System Modelling. This course includes a number of lectures which have been substituted by interactive Microsoft PowerPoint presentations that are studied by each student individually.
2. Systematic Problem Solving. A part on report-writing is available completely online, and includes assignments in which students collaborate in writing reports, using tools in Microsoft Word such as 'Insert Comments' and 'Track Changes'.
3. Management of ICT-oriented Organisations. In this course, individual students can access video fragments of parts of the lectures, and can join electronic discussions on statements provided by the teacher.
4. Sustainable Development. In this course students play a simulation game dealing with the ozone problem. The game has been adapted so that all communication between student groups takes place via the computer.
5. Engineering Design Problem Formulation. In this course, videos of lectures and other meetings are exchanged between Delft University of Technology and Carnegie Mellon in the USA, and the students discuss these videos in their own language group.

The fifth course mentioned (Engineering Design Problem Formulation) in this list of courses involved in the first cycle of design, development, implementation and evaluation, is described in a separate article in this issue (Herder et al.). The redesign and evaluation of the other courses will be explained in some more detail below.

Although the solutions chosen for each course are completely different, the teachers were very appreciative of the discussions taking place within the Line 3 group meetings. The first reason for this is that they received many useful comments on their own material from other teachers. They especially appreciated the practical do's and don'ts from teachers who are familiar with their students. The second reason is that they learned much from discussing their colleagues' material. They learned new ways of teaching and new approaches to the educational problems they have in common.

They also appreciated the structured way of tackling the redesign of their own courses. On their own, they probably would not have adopted such a systematic approach. Furthermore, they are enthusiastic about the availability of an ICTE expert and an educational consultant, who could point out the critical aspects of their preliminary designs and action plans.

Preliminary results and experiences of the Line 3 activities were presented in the second two-hour seminar which took place in January 2001. Such a seminar is one way of disseminating the work which has been done by the group to the faculty. The attending TPM teaching staff was very enthusiastic about these results.

3. Results of the activities undertaken as part of the first cycle of line 3

The first cycle of design, development, implementation and evaluation will be discussed below for the four courses briefly mentioned in the previous section.

3.1 Computer assisted instructions within a course on quantitative dynamic systems modelling

Part time SEPA students are often not able to attend all the (evening) lectures. In order to facilitate these students, several computer assisted instructions were developed for a course on dynamic systems modelling. These computer assisted instructions can be studied instead of attending the lecture.

The computer assisted instructions include theory and practice exercises. Each of the instructions takes a student about thirty minutes to complete. The instructions are based on the idea that the transparencies shown during lectures contain the essence of the theory. The computer instructions show the transparencies with additional explanations at the bottom of the screen. Students can choose to read the explanatory text, to switch off the text at the bottom and hear a narration, or to have both. On specific pages, students can click on a hyperlink to do an exercise, and then check their answer. No computer programming was involved in developing the instructional software for this course, the standard software Powerpoint was used.

In order to investigate whether the students appreciate this type of instruction, the students were asked to attend regular lectures for the first two lectures, and instead of the third lecture, the students were asked to study the computer instructions. After having completed the computer instructions, they were asked to fill out a brief questionnaire. Twenty, of the approximately forty students, filled out the questionnaire. Eighty percent of these students consider the computer instructions to be useful. However, none of the students think the instructions should replace the lectures. Most students state that it would be useful as an addition to the lectures. The students regard the practice exercises to be useful, but thirty percent of the students indicated that these require further development in order to provide

more feedback to their own answers. Most of the students indicated that video images of the teacher are not needed as part of the instructions. The most important positive aspect is that the students can determine their own time and pace. On the negative side they mention the absence of someone to answer their questions.

The general conclusion with respect to the instructions about the modelling theory is that students do appreciate the computer instructions, but see them as being supplementary to the lectures. Because they were initially meant to be used instead of lectures, we should think about how they can play a role within the context of the lectures, as well as being suitable for students who happen to miss a lecture. The results of the evaluation also indicate that the number of practice exercises should be extended and the feedback to the answers should be improved and extended. In addition, a solution has to be found for answering students' questions. A more extensive description of the redesign and evaluation of this course is presented by Daalen (2001).

3.2 Electronic peer review in collaborative writing within a module on systematic problem solving

A course on report writing is part of the first-year project module Systematic Problem Solving. The course on report writing was redesigned to be taught completely via Blackboard. Students and teachers no longer met; all instruction and feedback took place in the virtual classroom.

One of the aims of the module is learning to write a report as a group. In the traditional course, monitoring the collaborative writing process was difficult: the teacher only got to see the end result and could not control the peer-review process that preceded it, nor did the teacher have insight in each student's individual participation. Blackboard not only offers insight into the review process; it also offers new possibilities for its organisation. In this way, ICT has two points of impact: on the one hand it supports the writing process, and on the other hand it changes it.

Working with ICT encourages the use of electronic feedback functions, such as 'insert comments' and 'track changes' in Word, and it simplifies the organisation of the sequential peer-review process. A preliminary investigation was conducted to compare the effects of parallel review (all reviewers work independently) and sequential review (the output from one reviewer is passed to the next reviewer in line and so on), both with respect to the quality and quantity of the comments. Both forms of review were used in the writing course.

Both the guiding and monitoring of the collaborative writing process, and the use of electronic feedback tools were evaluated through a questionnaire among teachers and students. Compared to the traditional classes, the individual participation of the students in the collaborative work became clearer and it became easier for the teachers to monitor the writing process. It seems that the outline of the course, using ICT as the only communication tool, changes the role of the teacher. Some teachers missed the face-to-face contact with the students. The current research shows that this lack of personal contact becomes an issue when groups function poorly, or when their writing product is unsatisfactory. In these cases the communication between the teacher and students needs special attention; these situations still require a solution.

In the course, electronic feedback tools and different ways of organising online peer review were used. In the nearby future, feedback tools, like 'insert comment' and track changes' could play an important role in collaborative writing courses in engineering education, because they were highly valued by the students. From previous experiments it can be derived that electronic review directs the writing process, and influences the character of the comments. This would make ICT not just a good supportive tool for the collaborative writing process; it actually changes the collaborative writing process.

Students organised the peer review in both a sequential and a parallel way. They are divided about what is the quickest method: some say that sequential review is more efficient because reviewers do not give the same comment twice, others say that parallel review is quicker since several reviewers work at the same time. This issue requires further research. Students also disagree on which review method produces the best texts. If sequential review is appreciated more it is because of the possibility to make use of each other's ideas, whereas parallel review is chosen because of the preservation of the originality of one's ideas. This enables the collaborative writing group to make use of both types of review, depending on which purpose the review serves. A more detailed description of this course on report-writing and an in-depth analysis of the evaluation results can be found in Sjoer and Brakels (2001).

3.3 Integrating concepts of traditional courses with new technology in a course on the management of ICT-oriented organisations

A new course on the management of ICT-oriented organisations was developed in the autumn of 2000. The objective was to construct a learning environment using information technology in which the experiences of a manager can effectively be made available for students. The

topics of the course include the influence of ICT on liberalisation, globalisation, market development, management style and management practice. The primary teacher in this course has extensive experience as a manager, and the aim was to teach the students the do's and don'ts of running an organisation.

In addition to the lectures, the course was enriched with video fragments and electronic discussions, which were implemented in Blackboard. After each lecture, the professor recorded a limited number of short (2 to 3 minute) video fragments containing the highlights of the lecture. Special provisions had to be made within Blackboard in order for the students to be able to run the video fragments. The objective was to integrate the concepts of traditional courses with new technology such that the overall effectiveness would be improved. The duration of the course was three months. At the end of the course, the students were asked to evaluate the course using a predefined evaluation form. Results showed that the new course setup was effective and the specific way ICT had been applied had a significant added value.

3.4 A simulation game to teach aspects of sustainable development

A simulation game on the ozone hole/CFC problem, named Remodel, is used as part of a course on sustainable development. The main goals of the simulation game are:

- to show how companies and the government can react on a possible environmental problem,
- to show the product innovation process and its problems,
- how to take decisions under conditions of uncertainty,
- to show how interaction between companies and the government occurs.

The game has been played at Delft University of Technology, as well as at Groningen University 's Chemistry department for 9 years. It takes about 6 hours to play. The game is played by 20 to 25 students. In general, the game simulates a ten-year period during which two CFC producing companies transform their production to alternatives for CFCs. In that process, the government might introduce legislation and/or subsidies. In general the companies go through several years of losses, and sometimes bankruptcies occur.

As part of line 3 the Remodel simulation game was adapted. In the conventional way of playing, the communication between various groups occurred via written notes. This is important to prevent too many interactions. The communication between groups is now

completely handled by a local area network (LAN). This LAN also distributes the game information to the participants (financial results, environmental performance, and government regulation).

The aim of the adjustment was to reduce informal interaction between students and to play the game more efficiently for the game master. Every group was given a notebook and a separate room to work in. A database system and an electronic learning environment were developed and used.

Playing the game with an increased use of ICT tools improved the efficiency and quality of the simulation game. By reducing the contact between the students, the game is a more efficient tool for learning. There is however a risk that the level of 'inclusion' of the participants drops. Especially if there are periods in the game that certain groups are less challenged by events that need their attention. Further development of the game should be geared at preventing this from taking place. In addition, further work is being done on making the simulation game completely web-based so that it can be accessed from any terminal with a connection to the Internet.

3.5 Future activities

It was decided that the Line 3 activities should be continued for a further two years, as part of the TPM-wide ICTE project IMAGO. Some of the Line 3 teachers will be involved in a new cycle of design, development, implementation and evaluation, and some new teachers have been added to the group. Over the next year, another cycle will be carried out. New plans for this group include developing on-line homework for a course on systems in industry and the environment using the ETUDE testing system (Ven et al. 1999, Dopper and Ven 2001) and developing web-based course material for a course on sustainable development.

As part of the TPM-wide ICTE project, two sub-projects have been added to line 3, in addition to the group of teachers working their courses as explained above. The first of these is to develop didactic aids for students and teachers in project education in order to address common problems such as student participation and assessment of student projects. The second topic is the development of new forms of strongly interactive education in which modelling, simulation and gaming play an important role. This will, for instance, include the development of specific computer supported gaming simulations in which students play different roles, allowing them to learn about complex decision making situations.

4. Conclusions

The implementation processes described in this paper seem to fit into an academic organisation. An important aspect is to give employees influence in these processes, first by letting them think of solutions themselves, then by stimulating them and enabling them to realise this solution. This approach can only be successful if the management is willing to allow its employees to co-operate in steering these processes.

In this case, implementation is divided along three lines, which has proved to be very successful. The first line is directed towards the availability of technical facilities, for which this faculty relied on the university-wide ICTE programme. The second line is aimed at using these facilities to realise a broad, faculty-wide learning environment. This environment includes all courses, and aims to substitute face-to-face teaching practices with a format that includes educational technology. The third line is directed towards using technology in greater depth, in order to realise new innovative educational formats.

References

DAALEN C.E. VAN, 2001, A case study comparing student appreciation of lectures to computer assisted instruction on the topic of systems modelling, In I. GIBSON (ed.), *Proceedings SEFI seminar on Information and Communication Technologies in Engineering Education*, 2-4 May, Galway, Ireland, pp. 76-82.

DOPPER, S.M. and VEN, M.J.J.M. VAN DE, 2001, ETUDE, educational online assessment system. In I. GIBSON (ed.), *Proceedings SEFI seminar on Information and Communication Technologies in Engineering Education*, 2-4 May, Galway, Ireland, pp. 83-92.

MA, L., VOGEL, D. and WAGNER, C., 2000, Will virtual education initiatives succeed? *Information Technology and Management*, **1**, 209-227.

SJOER, E. and BRAKELS, J.K., 2001, Changing writing processes using ICT: electronic peer review in collaborative writing. In I. GIBSON (ed.), *Proceedings SEFI seminar on Information and Communication Technologies in Engineering Education*, 2-4 May, Galway, Ireland, pp. 64-75.

STEEL, J. and HUDSON, A., 2001, Educational technology in learning and teaching: the perceptions and experiences of teaching staff. *Innovations in Education and Teaching International*, **38**, 103-111.

VEN, M.J.J.M. VAN DE, STAAL, R.H.A. and STEHOUWER, A.M.A., 1999, The ETUDE automatic assessment system. SEFI Document 23, *Proceedings of a SEFI working group on Curriculum Development seminar*, held at Delft University of Technology.

WIERDSMA, A., 1999, *Co-creatie van verandering*, Delft: Eburon.

ZEE, H.J.M. van der (1997), *Denken over dienstverlening*. Deventer: Kluwer Bedrijfsinformatie.

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