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Using Workflow for Projects in Higher Education

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ABSTRACT

The WWW is increasingly used as a medium to support education and training. A course at the University of Twente in which groups of students collaborate in the design and production of multimedia instructional materials has now been supported by a website since 1995. Workflow was integrated with other components in the website to investigate whether workflow can help instructors and students to have a better overview of group progress. Our evaluation shows that the introduction of workflow does provide added value. Another outcome of the experiment is that the transfer of a business application (workflow) into the educational domain has highlighted some differences and similarities between educational and business processes. This article explores some of these issues as highlighted by the application of workflow in education.

INTRODUCTION

A number of courses at the University of Twente in the Netherlands routinely utilize a variety of web-based tools to support instruction and course management. This article relates to one such course, "Instrumentation Technology-1" (ISM-1), offered by the Faculty of Educational Science and Technology.

In the ISM-1 course, groups of students collaborate in the design and production of multimedia instructional materials, for example one of the assignments is to design and produce a WWW-based learning resource on the use of videoconferencing in education. The ISM-1 course has been supported by a website since 1995.

The course includes a series of lectures, but the main educational workform used in ISM-1 is known as *project-based education*. Project-based education is defined as problem oriented learning within the framework of a group project. In ISM-1 each project group works on a complex problem over a period of three months with the aim of combining theory and practical skills in the course of developing a high-level technical solution. This process involves not

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only problem-specific learning goals but also cognitive and social goals. Groups are expected to be oriented towards management and social aspects in the group process as well as towards solving the problem (Collis & Smith, 1997; Woerden, 1991).

Apart from running as a regular course in the undergraduate curriculum, ISM-1 is also being used as a testbed for experimentation with different approaches to supplying telematics support for the group-based instructional paradigm. These experiments are part of a joint research project ("IDYLLE") involving the Faculties of Computer Science and Educational Science and Technology. Within the IDYLLE project there is a PhD project entitled "Project-based Tele-learning: analysis, modeling, design and evaluation'.[1] The work reported here is conducted as part of this PhD project. Workflow is one of the techniques being investigated and this article relates to the experiments involving the use of workflow tools.

This article focuses principally on results from the experiments relating to the regulation of group-based projects using workflow. Other courses are also serving as testbeds for experiments relating to different aspects of group-based learning. One such is the "international tele-projects" where Dutch and Finnish instructors and student groups are working in distributed groups (Collis et al., 1997). These other experiments will not be discussed in this article.

The research questions relate to the applicability of workflow in the educational domain and to the efficiency gains resulting from the introduction of workflow. These questions were investigated through a combination of evaluation techniques: usability testing, expert reviews, student questionnaires, interviews, workflow audit trail information and use of Web browser statistics. One outcome of these experiments was that the transfer of a business tool into the educational domain has highlighted some differences and similarities between educational and business processes.

Our observations on this issue were tested out and refined as a result of meetings with the Dutch company Anaxagoras[2] who specialize in workflow solutions for business. We discussed workflow principles and practice with members of Anaxagoras staff and compared notes concerning the application of workflow in the rather different domains of business and education.

Firstly, we describe "The Workflow Experiment". In the subsequent sections, "Business Workflow versus Workflow in Education", "Differences between Business and Education Project Workflows" and "Some Similarities in Business and Education Project Workflows" we discuss the findings relating to the migration of a business tool into education, in particular the differ-

1. This research project is funded by the University of Twente. http://www.ctit.utwente.nl/Docs/projects/idylle/IDYLLE.htm

2. URL of Anaxagoras: http://www.anaxagoras.com

ences and similarities between business processes and educational processes which were highlighted by the experiment. In "Flexibility in Workflow" we discuss some of the requirements for flexibility which are not fully met by current generation of workflow systems.

THE WORKFLOW EXPERIMENT

The series of experiments with workflow took place during the 1997–98 academic year. The experiment began with usability testing of the intranet package Livelink[3] in the period September to November 1997. This period was also used for discussions with the instructor team of the course ISM-1. Through these discussions a clear and common understanding of the educational processes which were planned for the course was established.

Livelink was integrated with other components of the ISM-1 website and the first live experiment ran from December 1997 until March 1998. During this period all of the 60 ISM-1 students, working in eight groups, could conduct their projects with the additional functionality provided by the workflow application. A number of experts were asked to review the experiment while it was in progress.

Prior to this, in academic year 1996–97 for example, student groups had handed in their assignments as attachments to email messages generated by filling in CGI forms and submitting them via the course website. After comments were received, and any necessary rewriting completed, the deliverables were sent on to the webmaster who linked the deliverable to the course website. This multi-step process caused some unnecessary delays (caused by waiting for human interventions) and was capable of further automation. Two questions arose: 1) could workflow help instructors and students to have a better overview of the progress of the project groups during performance of the assignments and 2) could workflow improve automation of the process and reduce delays compared to previous cycles of the web-supported course.

Livelink Intranet combines a number of functionalities but for the 1997–98 workflow experiment only the workflow functionality of Livelink was integrated into the course website. Figure 1 shows the resulting client server architecture. The Livelink SDK client communicates with the Livelink server via the Livelink API (LAPI). This client is used to build the graphical workflows. User and group administration is effected via the web browser.

3. Livelink Intranet (version 7.2) is a product of OpenText. http://www.opentext.com

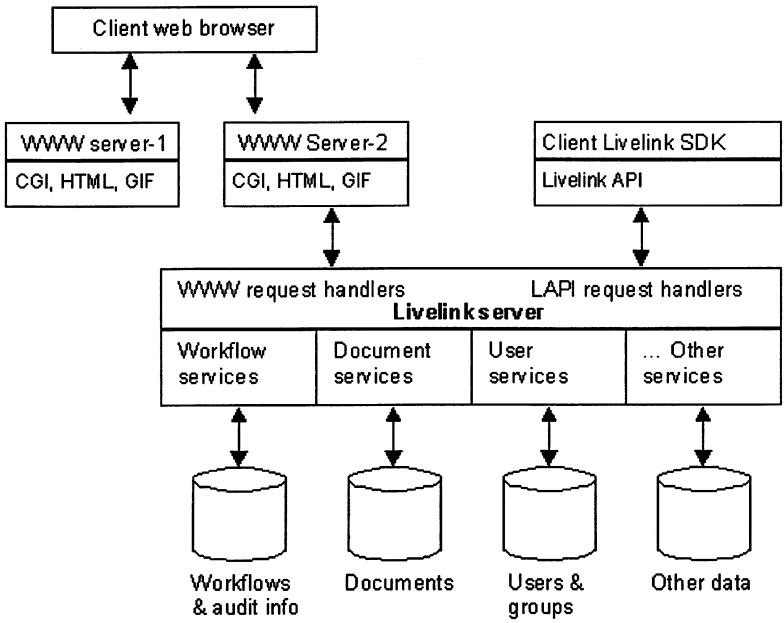

Fig. 1. Architecture integrating the services offered through the ISM-1 course website.

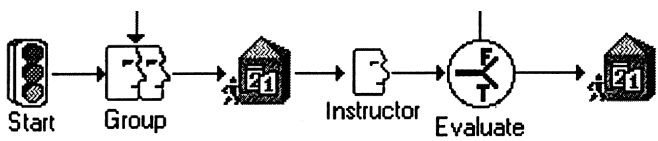

Fig. 2. An example of an educational workflow.

Figure 2 shows a graphical representation of a workflow as a Livelink activity diagram. The diagram shows part of the workflow, including a feedback loop, from the ISM-1 course. The start icon (traffic light) is at the left hand side; next the workflow proceeds to a double-faced icon which depicts a group step (in this example the student group works on an assignment). This is followed by a milestone icon, here representing a deadline for submission of a deliverable by the student group. The single-faced icon shows a step performed by a single actor; in this case the instructor commenting on the deliverable. The next icon shows a decision point; where the truth value of a boolean expression determines which exit is taken from the node. In this case the instructor may judge the deliverable to be “OK”, leading to completion of

the flow, or "not OK" leading to iteration via the feedback loop. All the student projects in ISM-1 were cast into Livelink workflows and the resulting workflows were used to drive the project-based part of the course.

BUSINESS WORKFLOW VERSUS WORKFLOW IN EDUCATION

The workflow paradigm was developed to support business functions and it therefore comes as no surprise to find that business orientations are reflected in workflow concepts and in the functionalities offered by workflow tools. We set out to discover how well these concepts and tools transfer to the domain of education and to what degree workflow, used to facilitate project management in web environments supporting group-based projects, can give added value as compared to other project management techniques being tested.

This issue implies a prior question, namely "What are the differences between business processes and educational processes?" In focusing upon this theme and discussing preliminary findings with workflow experts we formulated a set of typical differences, and also a set of similarities, between business and educational processes.

Workflow in business covers the spectrum from relatively short processes, for example in which a loan application is granted or not within a few hours, to processes which run over periods of months, for instance product development processes or in-house projects. The latter were seen as having more in common with the educational processes studied. We thus decided that the appropriate comparison to make was between educational processes and business processes which both run over a relatively long period of time (i.e., several months). Given these constraints, some differences and similarities were identified.

DIFFERENCES BETWEEN BUSINESS AND EDUCATION PROJECT WORKFLOWS

In Table 1 some differences between business and education project workflows are shown. These are discussed below.

Primary Goal of the Process

In education the primary goal is learning effectiveness. The efficiency issue is secondary and arises in education in only broad terms, for example the ques-

Table 1. Some Differences Between Educational and Business Settings when Applying Workflow.

Workflow aspect	*Business setting*	*Educational setting*
Primary goal of the process	Production efficiency	Learning effectiveness
Relationship between workflow actors	Contract based employee–manager relation Fixed hierarchy	Student–instructor relation based on weak "educational contract", partly customer like
Distribution of workflows	Instantiations of same generic workflow go to same actors	Duplicates of same workflow go to different actors
In-phase and out-of-phase workflows	Processes are out of phase	Within a course, group projects are in phase
Number of roles involved in the workflow	Number varies depending on the process	Usually limited to student and instructor role

tion whether certain workforms, such as project-based education, are economically viable given the resources that will be needed. This issue is addressed at the course level. Depending on the learning goals, some courses can be more expensive than others. In business, the question of whether the primary production process is efficient or not is critical; it can mean survival or failure of the enterprise in the open market (and "education" is not yet in an open market situation). In other words, efficiency is often mission critical in business processes but not (yet) in educational processes.

Relationship between Workflow Actors

It might seem that the student and instructor roles in the educational setting can be mapped respectively onto the manager and staff roles in the business setting. Based on our experiences however, it seems more appropriate to map the student role onto the customer role, since the student is the consumer of educational services and, especially with workforms such as project-based education, has more autonomy than a staff member reporting to a manager. In the educational setting the relationship between a student and the educational institution shares some aspects of the customer–company relationship. There is no exact parallel to the formal employer–employee contract; the "contract" between an educational enterprise and student is looser and more tacit (the students do have

to fulfill certain obligations to complete a course, and the institution has certain responsibilities toward the students). This difference in the relationships between actors involved in the workflow can bring a high level of negotiation into the educational processes, for example in connection with milestones.

Distribution of Workflows

We take a simple example of a bank loan request to illustrate this point. A bank has a generic process for assessing a loan request and deciding whether to grant a loan. This process can be expressed as a workflow. When a particular customer asks to borrow a particular amount on a certain date then the generic process is instantiated with the details of that particular request. Many loan requests will be received and thus many instantiations of the generic loan-request workflow will be launched. This is not duplication (why would a company do exactly the same piece of work twice over?) but instantiation. Furthermore, the recipient of each step of such business workflows will normally be the same business function (e.g., Finance Department or Personnel Department).

In contrast, in educational settings duplication is often appropriate. Exactly the *same* assignment may be distributed, i.e., given to a number of students, or in this case a number of student groups. (This may be in parallel, where different students perform the same task at the same time, or in serial, where the same assignment is given this year as last year.)

The former case—instantiation—can be handled by launching of the same default workflow with different field entries such as "customer name" or "budget request" which are filled in during initialization or in the first step of a workflow. This seems to be a frequently occurring pattern in business processes.

The latter case—duplication—can be handled, but not elegantly, in Livelink. Duplicate copies of a workflow destined for different recipients can be generated by spawning multiple copies of the original workflow. However any subsequent changes to the generic workflow are not inherited by the duplicates. If further changes are required the change must be made individually to each copy of the original workflow. This is inconvenient, it increases maintenance overhead and it brings extra opportunities for the introduction of errors.

In-phase and Out-of-phase Workflows

In traditional education the processes which make up a course are usually carried out in-phase. For example, different groups of students work at the same time on the same part of the course. In our example every project group starts the "design phase" of an assignment at the same time. In contrast there are

many business processes where instances of a process can be initiated at any time, for example triggered by an event such as a customer requesting a loan. Multiple flows in phase with each other are much easier to monitor simultaneously than flows which are executed out-of-phase.

This difference does not always hold, however. In distance education courses may be executed in-phase, but not necessarily so. The lifting of this constraint in educational processes introduces some of the added complexities found in certain kinds of out-of-phase business processes.

Number of Roles

The number of roles involved at the course level in education is quite small—the student or group interacts mainly with the instructors. In business quite a number of roles can be involved in the completion of a flow, depending on the nature of the process. For instance in a workflow describing the design process for a new car, the company management, many different sorts of technical experts and some external parties are involved.

This difference has some consequences for the user interface design. In Livelink the nodes in the activity diagrams are labelled by role, and this makes the visual representation quite informative in the situation where many roles are involved. Moreover in business the names of these roles, for instance "Finance Department", already imply some task information. In (project-based) education however the roles may only be "Instructor", "Group1", "Group2" and so on. Nodes labeled thus do not carry much helpful information. In this kind of situation it would be more useful if the visualization of the workflow focussed on tasks rather than roles, since, with only two main parties—instructors and students—the most important information comes from what tasks are to be carried out rather than who performs the tasks. For the instructor steps one can predict that reviewing or commenting will be the most likely tasks to be carried out. For the student groups there is no task related information in the diagram if the steps are labelled by role.

SOME SIMILARITIES IN BUSINESS AND EDUCATION PROJECT WORKFLOWS

Following our experience with workflow it became clear that there are also many issues that are similar for business and education. Some of these comparable issues are addressed in this section. An overview is shown in Table 2.

Table 2. Some Similarities in Educational and Business Settings when Applying Workflow.

Workflow aspect	*Business setting*	*Educational setting*
Workflow can lead to process reengineering	Business process reengineering	Pedagogical reengineering
Assessment based on end product	End product counts	Examination or product counts
Need for process monitoring	Managers monitor progress Instantiations of same generic workflow go to same actors Employee aware of progress	Instructors monitor progress Student aware of progress
Granularity of the workflow steps	Balance between detailing and professional self-management	Balance between prestructuring & self-management of learning
Use of workflow performance data	Improving personal skills Performance related bonuses	Improving personal skills Performance related marks
Adaptability of workflow is needed	Customer needs may lead to change in the process	Instructors want to be able to adapt when needed

Workflow can Lead to Process Reengineering

In business the introduction of workflow often results in some degree of process redesign, since setting up the workflow forces analysis of existing processes. The analysis and design decisions that have to be taken often lead to "business process reengineering" (Hammer, 1993). This phenomenon is a well known side-effect or benefit which can accrue from any kind of systematic analysis of (business) processes; here we find also (and this is not unexpected) that the same effect can occur with educational processes.

The application of workflow in the ISM-1 course has resulted in some redesign of the educational process. As an example of this, the flow in Figure 3 relates to the analysis of the "design phase" part of the student project. Here the activity diagram shows clearly that there is potential for delays in the assessment procedures since they involve quite a number of instructor comment steps, including loops where the instructor has the option to (repeatedly) send work back to the student groups.

The instructors, having inspected the workflow diagrams, confirmed that such delays actually had occurred in previous years and that these delays

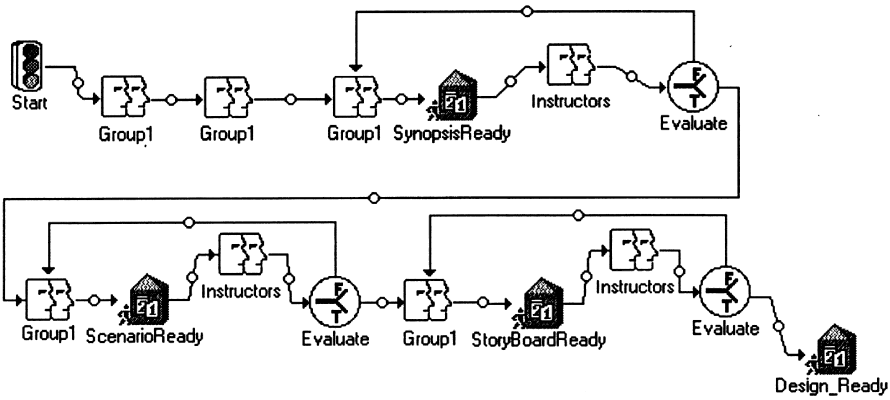

Fig. 3. Educational workflow with feedback loops.

had been a source of frustration for the students involved. For the revised version of the course the instructors decided to adjust their commenting procedure.

Assessment Based on End Product

Performance assessment in business, as well as in education, is often based on end products, with no explicit reference to process performance. In business a project team can be late in some stages of a project plan as long as they manage to finish their project in time. In education, course assessment is mostly based on examinations or products at the end of the trajectory. The "real" deadlines in project-based education are based on presentation of work plans or final products and on the official end of the course, after which other courses start. All other deadlines in between can often be renegotiated or even ignored if the major goals and deadlines are met.

This can be restated as the observation that business processes and educational processes may both include a mixture of hard and soft deadlines, with slippage and even skipping of some deadlines being possible so long as the critical path is not impacted and the final products are delivered.

Need for Process Monitoring

Performance monitoring can yield useful feedback on process execution, thus enabling actors to perform better in the future. In higher education there is not yet much of a tradition of instructor monitoring of group-based production processes. Students are expected to take care of their own work. However with

Status	Title	Performer	Relationship
OK	Brochure98pr3_Group3	&ltMultiple>	Manage
OK	Brochure98pr3_Group4	&ltMultiple>	Manage
OK	Brochure98pr3_Group5	&ltMultiple>	Manage
OK	Brochure98pr3_Group7	&ltMultiple>	Manage
Milestone Late	Brochure98pr3_Group1	&ltMultiple>	Manage
Milestone Late	Brochure98pr3_Group6	&ltMultiple>	Manage

Fig. 4. Status overview showing the groups' progress.

appropriate tools available, the introduction of some monitoring of the process has the potential to increase students' awareness of the process and its components. Giving students access to the so-called status overview in Livelink gives them a window onto the process itself. This status overview of the team's work can be viewed as part of the "group memory" (Rada, 1996) helping the group members to manage their own work. The instructors can also use monitoring to manage their courses more efficiently. They can identify progress and problems at a glance through the combined status overview of all groups as shown in Figure 4.

In business the imperative to improve performance drives the need for process monitoring, so that critical points in the processes can be identified and business risks can be minimized. Reporting on possible improvements can be supported with data collected in the day-to-day operation of those processes which are coordinated by workflows (Adelsberger et al., 1999).

Granularity of the Workflow Steps

When designing workflows it is important to address the appropriate level of granularity or detail. Putting too much detail into the workflows frustrates professional workers and students. Putting too little detail into workflows will give very limited process performance information. In education an extra reason for being careful about granularity is the fact that learning to organize one's work in a team is itself often itself a learning goal of a course (van Woerden, 1991). Overspecification of the process can reduce the students' opportunity to exercise this part of this learning process.

Use of Workflow Performance Data

Workflow software gathers different kinds of data with respect to the way the work process was carried out. This data can be the starting point for reengineering (see "Primary Goal of the System"). Also the data can be used to monitor the individual performance of personnel or students. The objectives of this monitoring can be:

- to assess individual skills in order to improve these through learning, coaching or otherwise
- to assess individual performance in order to differentiate in salaries or student marks.

There is a danger however that monitoring can have negative effects on personnel or students, for example by raising feelings of insecurity. For monitoring to be accepted and productive people in both business and education need to know beforehand how the data will be used. Open access to workflow performance data can help individuals to have a better view of their own performance. At the same time they may feel more secure about what sort of information is being collected and why.

Adaptability in Workflow

In business there is sometimes a need to adapt a workflow that is already underway, for instance to take into account wishes of customers that are expressed during execution of the process. In education there can be many situations in which instructors want to introduce some changes in procedures, for instance due to the availability of persons, rooms or equipment. The need to be able to adapt active workflows is recognized in the workflow literature (Sheth, 1997) but was only partly implemented by the package used in this experiment. Livelink allows for adjustment of steps in the main flow that are not yet active but subflows are locked as a whole once the first step in the subflow is activated. In the next section we try to identify what kinds of flexibility would be useful.

FLEXIBILITY IN WORKFLOW

Requirements for different kinds of flexibility have been identified in the current experiment. We make a distinction between *built-in flexibility* and *runtime flexibility*. Built-in flexibility is where the workflow description is defined to

accommodate certain kinds of variation; this possibility depends on whether these variations in the process can be completely predicted. Runtime flexibility in contrast addresses the need for defining part of the process details during execution of the workflow. In some cases the variations cannot be specified in advance (therefore runtime flexibility is the only solution). In other cases all the possible variations can be predicated in advance but runtime flexibility is preferred over built-in flexibility due to the fact that modeling all possible process executions makes the activity diagrams "unreadable" and this might involve too much effort to be feasible in practice. However allowing changes at runtime introduces other problems such that we have to question whether such complexity can be handled by students and instructors without help from workflow modelers.

Flexibility Needs in Education

Some flexibility requirements that can be identified in education are presented in Table 3.

In the following paragraphs we elaborate the concepts of built-in and runtime flexibility to explore how far flexibility requirements can be met by current workflow technology. For our tool Livelink, and other commercial workflow packages built-in flexibility is available. Runtime flexibility however is possible only to the extent that some packages allow changing details of predefined tasks on which work has not yet started.

Built-in Flexibility

Built-in flexibility copes with the situation where the specific requirements for flexibility can be identified before the start of the work (execution of the workflow).

Table 3. Flexibility requirements in educational settings.

FLEX1	Another instructor will comment deliverables
FLEX2	Even though students are late, the instructor wants to remind the students and give them some extra time
FLEX3	A condition for assessment is changed
FLEX4	The instructor only sets the major milestones (deliverables and deadlines), letting the group fill in process details.
FLEX5	A task description needs rephrasing
FLEX6	A task is added or cancelled
FLEX7	The ordering of the tasks is to be changed

Selection—Within the workflow definition a choice point leading to a number of alternative paths can be defined. During execution of the workflow one of these alternative paths is selected (Horn & Jablonski, 1998). A different kind of flexibility can be provided if the workflow is arranged such that the worker has the right to delegate a task. If necessary, the worker can decide whether or not the task should be delegated to another worker (FLEX1).

Exceptions—For exceptions that can be foreseen, the workflow description can contain event-based handling to accommodate exception conditions. In the WIDE-model, Grefen et al. (1998) use triggers that act on the transaction level to handle exceptions. An example is a "time-out" trigger for student assignments. As a result a reminder can be sent off automatically to those students who are late completing a task. The normal pattern is depicted in the activity diagram. Exceptional behavior can be handled by event descriptions (FLEX2).

Use of variables—If global variables are used in conditions in the workflow, the condition statements can be changed to a certain extent (FLEX3). For instance the threshold for positive assessment of a future multiple choice test can be changed from 15 good answers to 12 good answers (out of 20). Changing the threshold value thus will influence the course of events for those students scoring in the 12–15 range. If no variable were used, each active workflow would need modification. However it is worth noting that changing workflow variables afterwards will not affect the flow of events unless some "roll-back" mechanism can be defined for the workflow.

Runtime Flexibility

Runtime flexibility is needed when the workflow cannot be elaborated in full detail beforehand. Nevertheless workflow is useful since there is a need to outline, monitor and record the process for evaluation purposes or as input for future projects. This situation applies when supporting design-project teams who start the assignment with only a problem description and some constraints (FLEX4). So only a skeletal workflow can be defined in advance. Many of the process steps are to be identified during the process itself (Poel et al., 1995), leading to the requirement for dynamic adaptation of the workflow during execution. To explore runtime flexibility, we have to look into the state diagram for a task during a workflow execution, Figure 5.

A task is not visible to workers unless preconditions are fulfilled, for instance the completion of another task. The task is then moved to the task list of all users that are on the list of potential workers to do the task. As soon as someone starts working on the task, the task is removed from the other workers' task

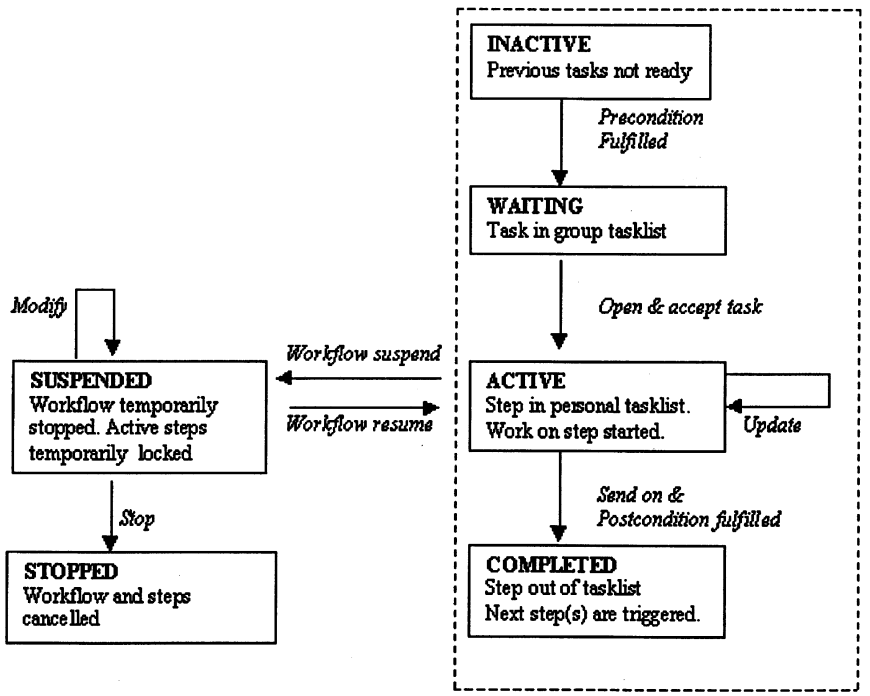

Fig. 5. States of a workflow task in the Livelink system.

lists and only appears on the tasklist of the user who started the work. The states on the left-hand-side can be reached from any of the states as a result of "suspend and resume" actions with respect to the workflow as a whole.

Adaptation—A suspension mechanism can be used to lock workflows in action that have to be stopped/deleted, or which have some task details that should be modified. In some implementations modifications are limited to changes to (sub)flows that have not yet been launched, however in others it is possible to change active (sub)flows (FLEX5, FLEX6, FLEX7). In the latter category however care is needed as sometimes changing the workflow details can violate necessary formal properties of the workflow and thus disrupt proper execution of the workflow. An illustrative example is given in Figure 6. In this situation tasks 2 and 3 are both active after completion of task 1. The precondition of task 4 is that both task 2 and 3 are completed. If however task 2 is deleted during execution, completion of task 3 will not trigger task 4 unless the precondition of task 4 is changed along with the deletion of task 2 (consistency property). To prevent workflows from becoming inconsistent, most

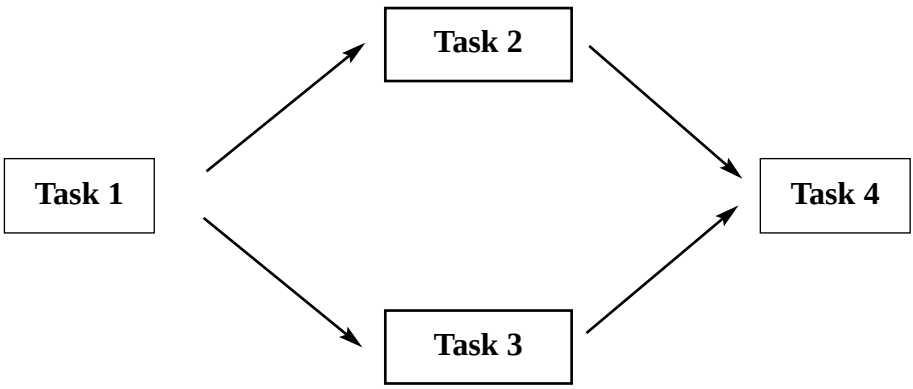

Fig. 6. Example of workflow failure: Task 1 is finished. Both task 2 and task 3 are now active. Task 4 will start if both task 2 and task 3 are completed. If task 2 is now deleted, task 4 will never be activated and deadlock will ensue.

commercial workflow packages only permit runtime changes in parts of the workflow that are not yet active.

Runtime modeling—The highest degree of flexibility is given by runtime modeling. This means that parts of the structure and content of the workflow are left undefined in advance (represented only as "clouds") and are then defined dynamically during execution. In an extreme case, only the start and end steps are predefined, and all the intermediate structure and content is defined dynamically by the actors during execution of the workflow. For example, instructors could identify only the first step (assignment) and the last step (deadline and constraints for final deliverable). Each student group is then asked to model their process into as many details they can foresee, only modeling more detail when possible and as needed (FLEX4). Both instructors and students can use the workflow management functions to monitor their progress and to help give the group a shared understanding of their plans. At present this degree of flexibility is not yet offered by any commercial product known to us. It is however a subject of research in the workflow community (Klein, 1998).

CONCLUSIONS AND DISCUSSION

The experiment yielded a number of results. We concluded that the use of the World Wide Web for delivery of education enhances the possibilities to offer an integrated learning environment including a range of services such as

course and project management facilities. We found that it is possible to represent project work using the workflow paradigm. Project work can be broken down into steps and translated naturally into the workflow idiom. Visualization of these steps, including milestones, was found helpful by all actors.

The evaluation work completed to date indicates that the introduction of workflow has provided added value as perceived by instructors and students. Instructors feel that they have better and more up-to-date overviews of the group work and a better and more shared understanding of the status of the performance of the student groups.

Students acquire portfolio-like group archives of their design-and-production deliverables together with the instructor's feedback comments. Running the workflow means that this portfolio is automatically built up and is accessible through a web browser independently of time and location. For students, the major benefit seems to lie in access to this portfolio. In interviews, most students acting as group manager gave as their opinion that workflow contributes to improved group performance and helps them in checking what is to be done and what their group's progress is (5 positive versus 2 negative responses). However the workflow administration was not kept up to date by the group managers in those weeks where only reporting on progress was to be done. A preliminary interpretation is that their focus was primarily on the progress of deliverables and maintenance was seen as an overhead with insufficient added value.

We applied a workflow tool designed for business settings in the educational domain. Consequently some differences between business and educational settings are reflected in the results. Most of all, in business an efficient path is laid out, presenting only information and tasks that are relevant at that time. In contrast in educational projects students are expected to learn to plan their project, and to learn to find the right information as part of the learning goals. If these educational characteristics are taken into account, further improvements in course management and implementation using workflow can be achieved.

Apart from differences we have also identified a set of similarities between business and education settings showing that many implementation issues are comparable and have to be taken into account when applying workflow.

Some specific drawbacks were identified: the workflow tool is not suitable for direct use by instructors. A workflow specialist is needed, which complicates the educational "production chain" and makes it vulnerable to delays. Furthermore last-minute adjustments occur in every course and more adaptation of the workflow should be possible, preferably at the instructor's desktop.

For more detailed results see (Veen et al., 1998). The (present) inability of the tool to provide this flexibility proved to be a problem. Suggestions for more flexibility are given.

We conclude then from the results of the first set of experiments that workflow can indeed be applied in a distributed educational context and can bring efficiency gains over the previous situation, but that we must take cognizance of certain characteristic differences between business and educational processes and be aware of the features and limitations of current workflow tools.

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REFERENCES

Adelsberger, H. H., Körner, F. X., & Pawlowski, J. M. (1999). Continuous improvement of workflow models using an explorative learning environment. In Collis & Oliver (Eds), *Proceedings of EdMedia Conference*. (Available at: http://www.aace.org.)

Collis, B., Andernach, T., & Diepen, N. van (1997). Web environments for group-based project work in higher education. *International Journal for Educational Telecommunications, 3*, 109–130.

Collis, B., & Smith, C. (1997). Desktop multimedia environments to support collaborative distance learning. *Instructional Science, 25*, 433–462.

Grefen, P., Pernici, B., & Sanchez, G. (1999). *The WIDE project: Database support for workflow management*. Kluwer Academic Publishers.

Hammer, M., & Champy, J. (1993). *Reengineering the corporation*. New York: Harper.

Horn, S., & Jablonski, S. (1998). An approach to dynamic instance adaption in workflow management applications. Contribution to the CSCW98 workshop on Adaptive Workflow Systems, Seattle, USA. (Available at: http://ccs.mit.edu/klein/cscw98/paper21.)

Klein, M. (1998). Towards adaptive workflow systems. CSCW98 workshop, Seattle, USA. (Available at: http://ccs.mit.edu/klein/cscw98/.)

Poel, I., Rip, A., & van Vught, F. (1995). *On design methodologies: Design in technical sciences* (Part 2). University of Twente, the Netherlands. (In Dutch.)

Rada, R. (1996). Coordination and reuse. In R. Rada (Ed.) *Groupware authoring* (pp. 85–102). Academic Press.

Sheth, A. (1997). *From contemporary workflow process automation to adaptive and dynamic work activity coordination and collaboration*. Workshop on Workflows in Scientific and Engineering Applications, Toulouse, France. (Available at: http://lsdis.cs.uga.edu/~amit.)

van Woerden, W. M. (1991). *Project-based learning*. Thesis, University of Twente, the Netherlands.

Veen, J. T., Collis, B. A., & Jones, V. (1998). *Applying workflow in web-supported projects* (pp. 216–226). Proceedings of the Computer Aided Learning in Science and Engineering, CALISCE '98 Conference. Center for Educational Development, Chalmers University of Technology, Göteborg, Sweden.