Workflow Driven e-Learning: Beyond Collaborative Environments

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Abstract: *E-learning is emerging as a significant web technology, sought by core educational institutes, organizational training, skill development centers as well as the diverse life-long learning communities of today. Many e-learning products and tools have been developed and deployed, which focus on specific aspects of learning. In this paper, we will present an approach to e-learning that aims at treating e-learning as a web information system with people, databases and processes, and not merely a tool for building intelligent web-sites. We identify the essential components of such a system in the light of a successful deployment of a workflow driven e-learning service, Flex-eL. We will present the architecture of the Flex-eL engine, as well as its supporting tools and functions, and illustrate how this amalgamates to a comprehensive e-learning environment. Lastly, we will discuss the impact of this approach on advanced workflow modeling and enactment issues, specifically modeling of flexible processes, advanced coordination of parallel activities, and batch handling of work list activities*

1 Introduction

Today's corporations, including educational institutions, are evolving into virtual organizations. Both telecommuting and downsizing are resulting in more people increasingly working from home and in small businesses. They are often coming back to universities and training organizations to upgrade or change their skills. Organizational learning and life-long learning are becoming increasingly important for any type of organization. There is growing evidence that restructuring of the communication infrastructures has had a fundamental impact on the educational sector, enabling unique communication patterns, increasing demands on the teachers and learners, and changing forever expectations of all parties involved in the educational process: students, teachers, parents, university management and administration.

In addition to the external factors influencing the educational sector, equally powerful internal factors can be identified, such as a diversifying student population, new learning and teaching methods, an increasing number of flexible and on-line courses, just to name a few. More and more part time, mature age and international students with a wide variety of educational, professional and cultural backgrounds are coming to the universities, schools and training institutions. They are increasingly distributed globally and have diverse learning needs and learning styles. Flexible e-learning solutions are required to meet their needs. The challenge is not to use new technologies to re-create traditional education systems, but rather create new learning environments, providing improvements to both teachers and students, and enhance the quality of education [MO00], [SO01].

An essential characteristic of e-learning is ubiquitousness. Students need the service anytime and anywhere to match their own pace and learning style. The idea of high quality learning experience is not to move from teacher-centered to technology-centered learning but rather to student-centered learning. Learning technologies must be geared towards providing greater flexibility in supporting and enhancing learning experience. A common misinterpretation of flexibility is lack of coordination. In an educational system, where for centuries, guidance, mentoring and control have been the driving forces, suddenly expecting the same quality of education minus some, if not the same level of control, is surely unrealistic. On a continuum of teaching and learning practices, we see the traditional class room at one end dominated by a culture of strict control, and the totally flexible web based course offerings, which merely provide the resources, and collaborative tools at the other end. We see effective e-learning as the mid ground of this continuum.

In this paper, we will first present an overview of related technologies. We will then identify the essential components of an effective e-learning environment. On the basis of these components, we have developed and deployed a workflow driven e-learning system. The next section will introduce the Flex-eL system and demonstrate how it amalgamates to an effective e-learning environment. Finally, we will summarize some of our experiences from Flex-eL, in particular how it provided an insight into modeling of flexible processes.

[1] The work reported in this paper has been funded in part by the Cooperative Research Centres Program through the Department of the Prime Minister and Cabinet of the Commonwealth Government of Australia.

2 Related Technologies

There are many research and commercial web-based educational products that have been developed and deployed all around the world. The most popular ones include Lotus LearningSpace, WebCT, BlackBoard, TopClass, etc. [CIT01], [UT01]. Most products provide two major types of tools: Learner tools and Support tools.

Learner tools includes web browsing: multimedia, security, bookmarks, etc; asynchronous sharing: email, newsgroup, file exchange, etc; synchronous sharing: audio/video chat, whiteboard, virtual space, teleconferencing, etc; and, student tools: progress tracking, searching, motivation building, etc.

Support tools include: course: planning, managing, customizing, monitoring, etc.; study modules: instructional designing, information presentation, testing, etc.; data: on-line marking, managing records, analyzing and tracking, etc.; resource: curriculum managing, building knowledge, team building, etc.; administration: installation, authorization, registering, server security, etc.; and, help desk: student support, instructor support, etc.

Generally, these products emphasize on learner tools such as web-based multimedia study material. Although several leading packages provide a wide range of powerful support tools for various aspects of course management, most of them are still "task-oriented" rather than "process-oriented". Some of their deficiencies can be identified as follows:

- Tools are designed to support individual learning tasks rather than the learning process.
- There is no integration of technologies that support various aspects of the study process.
- Tools offered by educational packages are content-free resources and their adoption and integration into the study program relies on the experience of the course designer. That often results in the technology-centered learning process.
- Every educational package provides a limited set of tools and inclusion of the new tools as they become available could be very difficult.
- Generally, the educational package is used to support several individual subjects through separate accounts or workspaces and no interaction between different "accounts" is possible.
- Tracking of student learning progress is very difficult. There is very limit coordination between student's study material and time management.
- Monitoring of individual student study progress is often neglected.

In summary, most of these products make the assumption that by providing asynchronous and synchronous collaborative tools and multimedia study material they can replace the learning experience of students in class rooms. However, in a class room based course, the instructor has the responsibility of maintaining the order in which course material is to be taught. He or she is also responsible for ensuring that all students are keeping up with the course material. Typical e-Learning systems generally loose this coordinating role of instructors. This lack of guidance and control from the e-Learning application has an adverse affect on the quality of teaching and learning.

We believe a middle ground is more appropriate for effective e-Learning. An ideal e-Learning system should provide students with flexibility to learn at their own pace but at the same time it should also provide guidance to the student in going through the course requirements appropriately. It should also make the instructor an essential part of the student learning process in order to ensure that a student is meeting the course objectives effectively. All this can be achieved only by developing an e-Learning system as a web information system instead of building a course web site with a set of collaborative tools.

3 Essential Components of e-learning

Providing an effective e-learning environment, as described above, will have at least three essential components:

3.1 Learning Material

Online learning material is basically a means of replacing the traditional lectures. However, online material has to be appropriately designed to cater for the specific characteristics of e-learning. Several technologies already exist that provide an effective means of presenting the learning material, such as authoring systems, publishing tools and multimedia presentations that incorporate video with text, graphics and animation. Determining which particular approach would work for a particular group of students is a very subjective issue, that involves several factors such as the prevailing culture, familiarity with technology, and most

importantly the actual subject content. Online learning material is typically supported with textbooks and tutorials or practice exercises, self assessment, additional readings, case studies etc.

In certain areas of learning, special purpose learning tools may add greatly to the concept of self-directed learning. Such tools can typically be used for experimentation and practice, as is often required in science subjects. One example of such a tool is the SQLater [DSTC01], which provides an engine for SQL query evaluation. Thus students are able to formulate SQL queries from a given (large) pool of questions relating to a given database. They are able to execute their queries as in any query processing environment, but are also able to check whether or not their formulation is correct. This tool has proved to be of immense value in database courses with a query component. Tools along similar lines can be envisaged for other subject areas, and would obviously aid greatly in extending the resources available for e-learning environments.

3.2 Collaborative Tools

In the absence of the traditional classroom, there is a need to provide some means of collaboration and/or interaction between students and teachers, and also between student groups or individuals. Several collaborative tools have emerged to provide a substitute to the face to face communication. These include technologies such as chat communities, teleconferencing, whiteboards, newsgroups etc. These technologies are already fairly mature and readily available as part of e-learning systems or independently.

3.3 Coordination

In addition to learning material and collaborative tools, we see another essential component of e-learning, which is, to provide coordination and control of the study process. In traditional environments, it is the instructor's role to keep things in order and provide guidance regarding the order of study and assessment tasks. In current e-learning environments there is no effective compensation of the instructor's role to ensure a satisfactory student progress. It is left to a large extent to the student, to plan the learning activities.

We believe that existing e-Learning technology primarily targets the first two components, learning material and collaborative tools. Their support of coordination is generally weak. The system we will present in the following section, Flex-eL, attempts to fill this gap by using workflow technology to provide coordination services for learning processes.

4 The Flex-eL concept

The Flex-eL project is based on the concept of using workflow technology to support learning in order to provide an innovative, workflow-based, fully flexible learning environment to deliver education courses. Workflows are process oriented business information systems that offer the right tasks at the right point of time to the right person along with resources needed to perform these tasks. Workflow technologies are capable of supporting control and enforcement of business rules enabling coordination of business activities, effective time management and monitoring at various levels for various categories of users, automatic support for dynamic modification of the existing processes and relatively seamless integration of various tools and applications [SO99].

Flex-eL aims to support the concept of flexible learning pathways through courses consisting of modules that, in turn, are managed by a number of learning activities. Our approach is to create student-centered learning that starts from the concept of the integrated study process that is carefully designed based on the latest educational models and supported by workflow technology. Effective integration of various learning activities is enabled by the study guide while workflow technology offers the right tasks i.e. learning activity at the right point of time to the student along with learning resources needed to perform these tasks. One of the main advantages of workflow technology, which is used as a backbone of Flex-eL, is to provide better integration of the new resources and new tools as they become available in the future.

Generally, workflow technology is applied for traditional workflow processes like sales order, purchasing, etc. and the learning domain is a very non traditional application for workflow technology. However, e-Learning activities can be modeled and managed as business processes. Treating e-Learning as business processes opens up new directions to build web based e-Learning systems. The idea of utilizing workflow technology to manage the learning and teaching activities came from the nature of the study process. A well-integrated study environment should include components such as learning and assessments into one fully system supported stream of activities. Workflow technology can then be used to manage these learning activities for different roles.

The design of Flex-eL takes the workflow technology as the main backbone infrastructure and incorporates other technologies and tools around it to achieve a complete learning environment. Figure 1 shows the Flex-eL technology architecture.

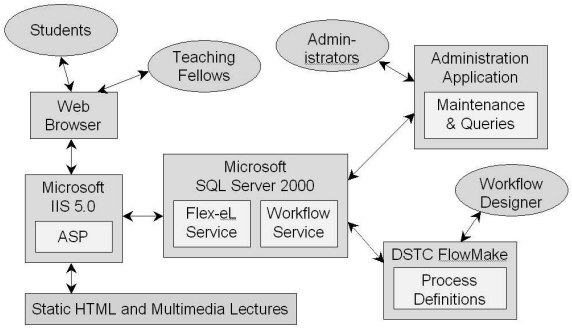

Figure 1. Flex-eL Technology Architecture

A process-modeling tool called FlowMake is used to capture the study process. The course activities and associated roles are identified and modeled using the tool. This predefined workflow model is then deployed in the workflow server which has been built upon Microsoft SQL server 2000. Flex-eL uses web interface to provide students and teaching fellows accessibility to the system. The study materials are presented in multimedia form. Flex-eL provides internal functionality to build study contents. However, it is also possible to link learning activities to any externally available learning material, thereby providing better integration of new resources and tools as they become available. The administration features allow setting up courses, enrolling students, and managing workflow processes.

For setting up a new course, we define the instructors in the database that are responsible for managing the new course and assign them a teaching fellow role for the new course. We then define the new course that includes creating study materials, defining tasks needed to be performed in the course, defining assessments, and scheduling assessment time slots. After that we model and export the associated process definition for coordinating the course into the workflow repository and link it with the course definition. For example, activities in the process model are associated with relevant study materials and performer roles. Exporting the process model in to a workflow repository from FlowMake also includes generating the VML code for the course process visualization. The exported process model provides a process template for the course. Figure 2 illustrates such a process template. Each course is associated with one or more workflow process templates that define the order of course activities. One of these process templates is assigned to each student when he or she enrolls in the course.

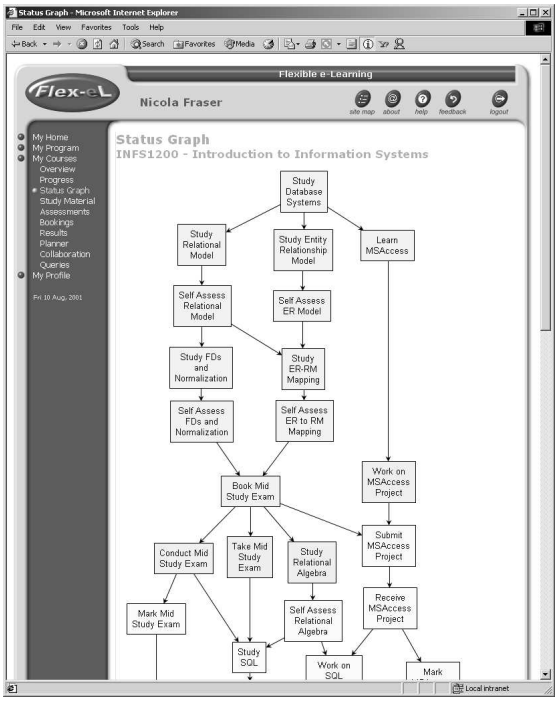

Figure 2. Flex-eL course status graph

This visualization provides the information necessary to understand the interactions between workflow tasks and the decision processes. Students can use this workflow functionality to visualize their current study progress and also plan for their future study pathways. Similarly it helps teachers monitor a student's progress at a glance.

It is also possible to have more than one process template for the same course. For example, one process template may have only a single assessment at the end of a study period. Another process template may have smaller assessments during the study period. The teaching fellow and student can decide between themselves which type of process template would be useful for the student.

This is one of the Flex-eL's unique features that offer tailored learning pathways and flexible study styles for students. Each student can learn at their own pace, without worrying about deadlines for assignments and assessments. By relaxing time constraints the flexibility for individual time management is achieved. Flex-eL's learning strategy also has the potential to speed up the studying processes. Students could complete their courses as soon as they have finalized all the required tasks assigned to them by the system. As for teaching

fellows, the workload is also reduced because assessment and consultations times can be booked prior to the actual meeting. Overall, the learning and teaching effectiveness of courses is enhanced due to the efficient and flexible time management.

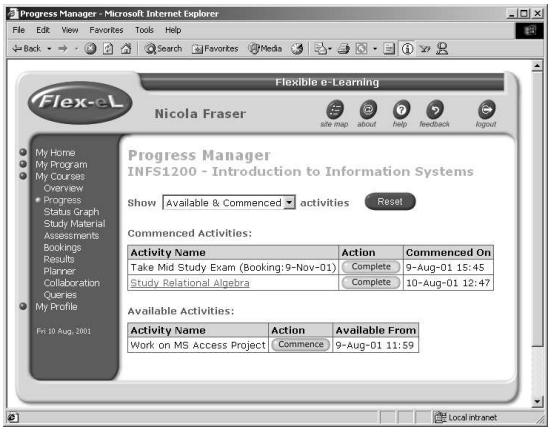

Figure 3. Flex-eL Progress Manager

Workflow technology offers many features that can significantly improve e-learning environments. It can automatically assign the right task to the right person at the right time. As shown in Figure 3, the progress manager provides a list of activities for a student to work on based on his current progress. This work list is generated automatically from the information provided by the Flex-eL workflow service. Work lists are also created for teaching fellows to handle student assessments and markings. Flex-eL allows several teaching fellows to effectively share the work between them. For example, when a marking activity becomes available in the workflow, it is made available to all teaching fellows that can mark that particular exam on the basis of workflow role assignment. When one of the teaching fellows *Commences* that activity, it is removed from waiting lists of other teaching fellows. Similarly, for students, Flex-eL coordinates the availability of course material, study and assessment activities by utilizing the embedded workflow functionality. Thus workflow technology provides an excellent framework for managing the coordination of activities among students and teaching fellows.

In addition to the coordination aspect, Flex-eL also provides an extended collaboration environment. During the study phase, the progress of each individual is captured by the workflow system. Therefore, the students have the ability to find out the information about other students who are working on the same activity. Such features encourage collaboration among students. The teaching staff is also able to monitor the progress of individual students and may provide assistance to individual students. Flex-eL provides effective collaboration between students themselves as well as students and teaching staff. In contrast to the other online learning management systems that provide chat room or discussion boards for collaboration, Flex-eL helps to identify groups of people suitable for collaboration.

Workflow enabled learning, as discussed above, provides the essential coordination, monitoring and planning functions for the effective management of the study process. Lastly, Flex-eL also has additional functions which allow integration with interactive learning tools and an effective media for presentation of course material.

5 Experiences from Flex-eL

We successfully deployed Flex-eL version 1.0 at the University of Queensland for two postgraduate courses and one undergraduate course. Our experience with postgraduate students (especially part time and working students) showed a marked decrease in the number of drop outs from the course offered in Flex-eL mode. We consider this to be a major success of the Flex-eL concept. In undergraduate, the flexibility was much appreciated by students who were willing and able to take high work load during the semester, and adjust the requirements of the Flex-eL course according to the (hard) deadlines of traditional courses. Another positive result was the students' motivation towards self-directed learning. Flex-eL students showed a greater tendency to go through the required readings, and a greater interest in the application of knowledge to interactive online tests as well as problem solving exercises.

On the basis of our experiences, we have identified several technical and design improvements that could be introduced in the new version of Flex-eL. We have also made several observations that, we believe, will help us in deploying future courses in Flex-eL environment. Below we report on how the deployment of Flex-eL provided an insight into some advanced workflow modeling and enactment issues.

5.1 Modeling of Flexible Processes

An important outcome of the analysis of study plans, was the need to model flexible workflow processes, that is workflow models which could provide a high level of flexibility so as to cater for the diverse student learning needs and styles. Although the need for flexible workflows is well established [AJ00], [SSO01], Flex-eL deployment provided an opportunity to study the

characteristics of such processes in a real life environment. Flex-eL study plans were built using a generic workflow definition language, primarily designed for modeling "production-style" workflow processes [Moh96].

Typically such languages based on workflow modeling standards [WFMC98], provide modeling constructs such as Sequence, Exclusive Or Split (Choice) Exclusive Or Join (Merge), And Split (Fork), And Join (Synchronizer). However, consider a scenario where a process generates a very large number of instance types, that is, demands a high degree of flexibility. Suppose that a large number, say *k* number of paths are present within a choice-merge construct. Each of these paths potentially represents a complex sub-process. There can be several such constructs within the process model, which may include nesting also. One can see that a typical workflow language may not provide a very elegant means of representing such a process. In order to seek some alternative way of modeling, some simple approaches are identified below:

- Flexibility by Definition: Flexibility may be built into the model through choice merge constructs. Limitations of this approach are obvious. This would result in a highly complex model, which in some cases may still be incomplete, that is unable to capture the diverse student requirements.
- Flexibility by Granularity: Flexibility may be achieved by encapsulating activity details within workflow tasks, and keeping sub-activities 'internal' (and flexible), or outside the direct control of the workflow [SI95]. This approach can be applied to a limited extent, but it cannot be used at a generic level without compromising the purpose of deploying workflow technology, namely to coordinate and control the flow of process activities. On the other hand the definition of the atomic activity is crucial. It is important to define the most appropriate granularity for each activity, so that the users are not repeating the same "available – commence – complete" cycle for unnecessary activities.
- Flexibility by Templates: Flexibility may be achieved by providing separate templates for a given (set of) instance type. This slightly improves the readability and consequently maintainability of the model. However, choosing an instance type from a set of templates rather than one model with many choices will have advantages only if the number of templates can be restricted to a reasonably small number.

A common disadvantage of the above approaches is that they still rely on a prescriptive model. Thus, not only is it cumbersome to model all choices in flexible processes, there may be choices which cannot be anticipated. To provide a modeling framework that offers true flexibility, we need to consider the factors, which influence the paths of (unique) instances together with the process definition. The experiences from Flex-eL initiated some interesting work in this area, which we have reported in [SSO01].

5.2 Advanced coordination of parallel activities.

Design of the study process workflow is very challenging and critical. Although we aim to provide maximum flexibility to individual study pathways, coordination between the teaching fellows and the students must be considered. For example, the assessment activity involves contributions from both parties. The definition of completing this activity should be independent for both roles so that one could not unnecessarily delay the other proceeding to the next activity. This revealed a very interesting aspect of workflow tasks, which are modeled in a fork (And-Split/Parallel) construct. Although a fork basically implies that the tasks may be executed in any order, the above identified the fact that a low-level dependency may exist between parallel tasks. For example a student activity to take an assessment and a teaching fellow activity to conduct the assessment become available in parallel. These activities may be commenced independently, but an additional dependency exists on their completion. That is, the student cannot complete the take assessment activity unless the teaching fellow first completes the conduct assessment activity. This identifies additional workflow functionality and need for advanced coordination of parallel activities.

5.3 Batch-oriented handling of work list activities

Although each student constitutes an instance in the study plan workflow, there is evidence that certain activities, especially from the teaching fellow's point of view may need a grouping of the student instances on the basis of certain factors. For example, marking an assessment for a group of students who appeared for that assessment together should conveniently be handled as a batch activity for the teaching fellow, rather than individual activities. This is a front end issue to a large extent, which allows a workflow client to group similar activities from a number of instances and handle them in a batch. However, it may also be approached as an

additional layer on the workflow scheduling service, thus extending the functionality of the basic workflow scheduler.

6 Conclusion

In this paper, we described Flex-eL - an innovative and flexible learning environment supported by workflow technology. We have identified some deficiencies of current popular e-Learning systems and proposed a new approach to overcome them by using workflow technology. We propose that a well-structured learning environment should integrate various aspects of learning. The underlying learning strategy of Flex-eL provides flexible learning pathways and possibly brings the virtual university concept closer to reality. We have also come across a number of challenges through the deployment of the Flex-eL system.

A main contribution of this research is the application of workflow technology in building an e-Learning environment. The workflow technology has traditionally been deployed to automate traditional business processes like procurement, inventory, expense approvals, etc. Our experiences clearly show that it could prove to be very beneficial in coordinating non traditional applications like e-Learning.

These experiences have helped us identify the issues that need to be addressed when deploying workflow enabled e-learning services, and have also revealed some interesting workflow modeling aspects, which identify a need to rethink some fundamental assumptions regarding workflow modeling and enactment.

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