Managing Collaborative Learning Processes in E-Learning Applications

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Abstract: *This paper argues that current E-Learning approaches do not take into account process-oriented nature of learning in traditional settings. This situation can be seen as one of the reasons why many E-Learning applications have disappointing results in learning outcome or efficiency of knowledge transfer. To remedy this deficiency in modern E-Learning a tool that supports management of collaborative learning processes has been implemented at University of Technology Graz. This paper presents that tool and outlines its implementation. At last, the paper discusses a number of directions for the future work to support collaborative learning processes in E-Learning applications.*

Keywords: E-Learning, Collaborative Learning Processes, Management of Learning Processes

1. Introduction

Although the process-oriented nature of collaborative learning in traditional settings is indisputable, both E-Learning in general and collaborative E-Learning in particular commonly neglect this fact. Typically, E-Learning adopts one of the following learning modeling approaches: the content-oriented, the tool-oriented, or the task-oriented approach [12].

Content-oriented approach is mainly concerned with management of learning content in E-Learning systems by supporting authoring, structuring, delivering, sharing, re-using, and querying of the content [1].

Tool-oriented approach is based on the underlying technological infrastructure. Learning sessions which follow this approach are organized around the use of a particular collaborative tool and thus they only reflect the technology [13].

Task-oriented approach deals with learning activities which the students need to perform. Those activities are typically structured in very simple learning sequences that the students need to pass in a sequential mode [2].

However, numerous evaluations that investigated improvements in learning outcome or efficiency of knowledge transfer in E-Learning had disappointing results [11]. There are several reasons for such an unsatisfying situation [3, 9, 10]. As a number of research studies and projects show one of the most important reasons is the lack of technological support for management of learning processes.

For example, one of such projects was the project called CORONET funded by the European Commission (IST-1999-11634). The main purpose of the project was to analyze, implement and evaluate a number of tools for support of collaborative knowledge transfer processes. Each of such tools utilized the current and advanced Web technology to facilitate and speed the flow of knowledge from people possessing that knowledge to people who need to acquire it by following a particular collaborative pedagogical approach in a process-oriented manner. Thus, processes such as Web-based tutoring, Web-based knowledge mining, Web-based collaborative writing, and collaborative project-oriented learning have been supported. The evaluation of the project results in respect to the increase of learning outcome by knowledge sharing and collaborative learning generally indicated improved learning effectiveness [4, 5].

Recent research identified the most significant technological deficiencies of the above mentioned E-Learning modeling approaches in respect to support for learning processes [6]:

- Lack of possibility to formally define a particular learning goal, which the students need to achieve, as well as a lack of possibility to automatically check the students' success in achieving that goal.
- Lack of possibility to define the learning procedure, i.e., the set of learning activities structured by means of certain pedagogical rules that lead students to achieving the learning goal [12]. These learning procedures might reflect sophisticated pedagogical approaches such as problem-based learning, collaborative writing, or

project-based learning. It is important to note here the difference between such learning procedures and simple sequences of learning activities from the task-oriented approach.

- Lack of possibility to map the learning procedure onto the available tools and the underlying technological infrastructure.

This paper presents a tool called Learning Process Manager (LPM) implemented at the University of Technology Graz that aims at supporting management of collaborative learning processes. The rest of this paper is organized as follows. The second section presents a sample learning process supported by means of LPM. The third section discusses implementation issues of LPM. Finally, the fourth section concludes the paper by summarizing directions for the future work in this field.

2. Sample Learning Process in LPM

The LPM system aims at providing a tool-support for a so-called learning process lifecycle. These tools include:

- Modeling tool where a particular learning procedure together with a number of learning activities is defined. In addition, learning content, tools, and pedagogical rules are associated with the defined learning procedure. Lastly, the modeling tool supports teachers in mapping the learning procedure onto the technological infrastructure.
- Execution tool that runs the learning process by executing the learning procedure (i.e. by following the pedagogical rules) and presenting the learning activities to students. In addition, the associated learning content and tools are made available for students.
- Monitoring tool that is operated by teachers to monitor and analyze the students' progress within a learning process.

Let us introduce here a sample learning process to practically illustrate behavior and execution of learning processes in LPM.

Suppose that we have a university course dealing with the basics of computer operating systems, in particular with the basics of the Linux operating system. There are 10 students who would like to participate in that course. The course is held by a university teacher who is currently on a research trip abroad. Therefore, the teacher would like to carry out the course in an online mode. However, the teacher does not want to have a typical Web-based reading course where the students simply read a number of documents prepared by the teacher. Rather, the teacher would like to involve the students in a learning process where they participate in discussions with their peers, collaborate with each other, and take part in online tests.

More precisely, the teacher has the following learning procedure in mind. First, the students are supposed to read through some learning content. The learning content includes a remote PDF document and a Web site on the basics of Linux, as well as a learning course prepared with an E-Learning system. Second, the students are free to write comments, ask questions, or brainstorm certain ideas from the learning course using the annotation feature which is available in the system. Third, the students are supposed to use a discussion forum provided by the E-Learning system to discuss a number of topics from the subject matter. The topics are predefined by the teacher. Fourth, the students need to take an online test using the test tool from the E-Learning system. Lastly, all students that achieve more than 50% of correct answers in the test finish the course successfully. All other students need to read an additional document provided by the teacher and then repeat the test. If the students fail the test for the second time they fail the course, otherwise they conclude the course with success.

Let us investigate now how this sample learning process is supported by means of LPM.

In the first phase of the process the teacher prepares the learning content by reusing some online material and by creating a learning course using an E-Learning system. Subsequently, the teacher creates the learning procedure by using a process definition tool offered by the LPM system. Lastly, the teacher maps the learning procedure onto the execution procedure by operating a process mapping tool from the LPM system. Here, the teacher instructs the LPM system which E-Learning system and which tools from that E-Learning system are needed.

In the second phase the students start their work with LPM by authenticating with the system and choosing the sample learning process. The system runs the execution procedure and presents learning activities to the students which they need to accomplish. Since the learning procedure created by the teacher is a simple sequential procedure the students get one learning activity at a time, i.e. a number of reading learning activities, a discussion learning activity, a test learning activity, and then if needed another reading learning activity and finally again the test learning activity.

Whenever a student finishes a particular learning activity the LPM system is notified and the student gets the next learning activity from the sequence. At any time the students can monitor their progress within the learning process, i.e. they always can see which learning activities they have finished (see Fig. 1) and which they still have to accomplish.

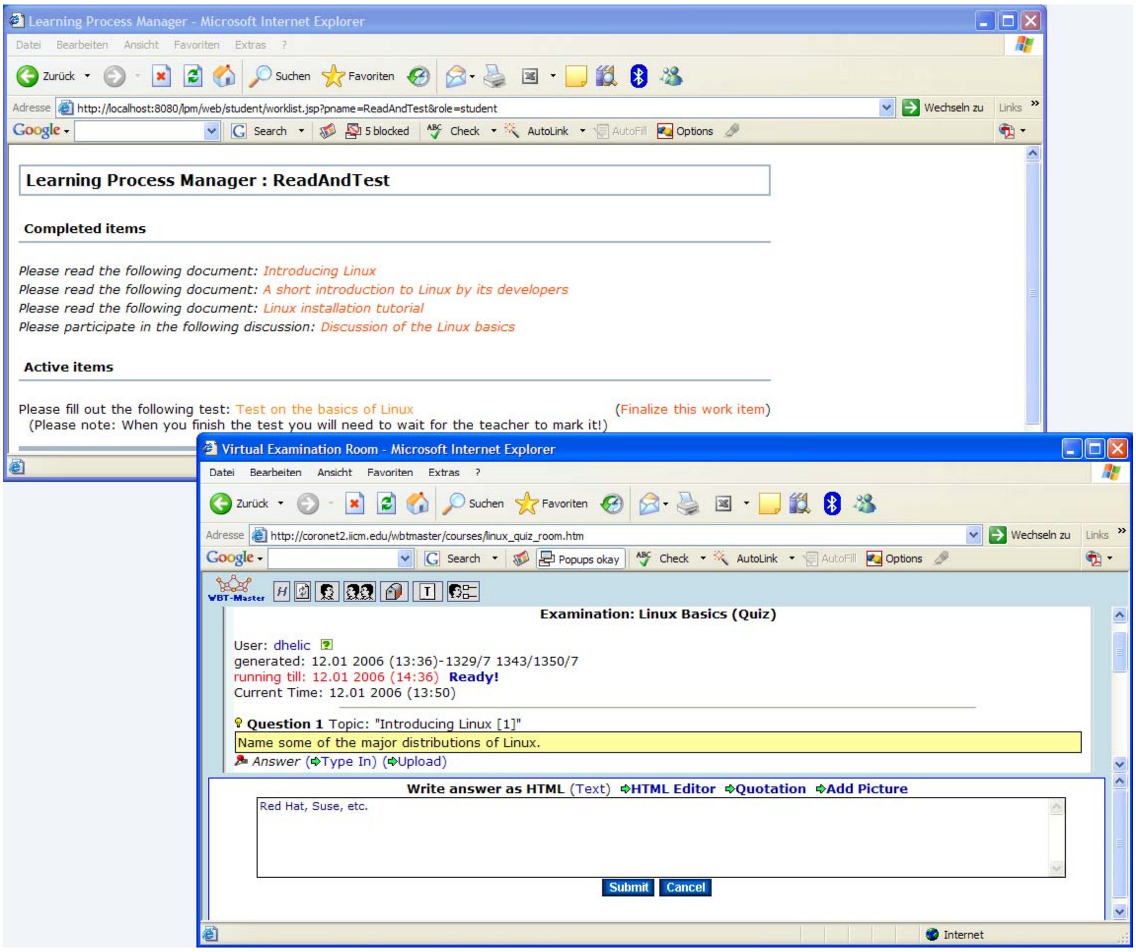

Figure 1. Student in a learning process

During the learning phase, the teacher monitors the students' progress using the LPM system. Additionally, the teacher discusses all course related issues with the students, answers their questions, or clarifies certain topics from the subject matter by using the E-Learning system.

Further, the LPM system provides certain working activities for the teacher. For example, whenever a student finishes the test the LPM system notifies the teacher. In turn, the teacher needs to revise and mark the student's test (see Fig. 2). At the end, the teacher submits the mark for the student's test to the LPM system.

In the third phase, which runs in parallel with the second phase, the teacher can use monitoring tools provided by the LPM system for analyzing of the learning process. For example, the teacher might notice that the students need a lot of time to read a particular document. The teacher comes to the conclusion that the content is not adjusted to the knowledge level of the students and adapts the content to an appropriate level.

3. Implementation Aspects of LPM

The LPM tool is based on the workflow technology. Workflow is typically defined as the automation of a (business) process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules [7].

The automation is achieved through a so-called workflow management system that manages and executes workflows represented in a machine-understandable way. Participants of a workflow can be either humans or software systems that execute tasks defined in the workflow in order to achieve a particular business goal. Thereby, the humans work with the so-called worklist (i.e., a list of activities to be executed by following certain rules) to achieve their goal.

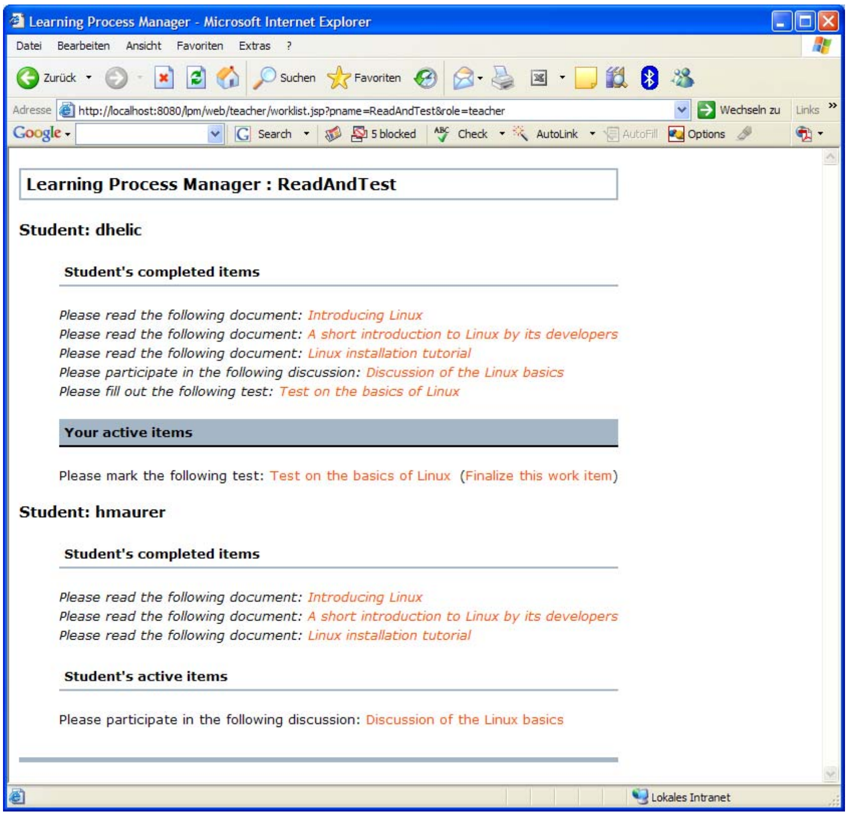

Figure 2. Teacher in a learning process

Currently, architectural principles such as Service-Oriented Architecture (SOA) and its particular implementation in the form of Web services are adopted by the workflow technology to achieve integration between Web-based software systems operating across the organizational boundaries.

Additionally, the current workflow technology is based extensively on Web standards such as Extensible Markup Language (XML) to facilitate document and data exchange, to create definitions of service interfaces or to manage interoperable representations of workflows [8]. For example, today workflows are typically defined using an XML-based language called Business Processes Execution Language (BPEL) which works with Simple Object Access Protocol (SOAP) and Web Services Definition Language (WSDL) based Web services.

The current implementation of LPM is based on an Open Source implementation of BPEL specification called ActiveBPEL. The engine is capable of executing processes defined in BPEL and provides monitoring and analyzing tools. Generally, BPEL processes are simply Web services that orchestrate other Web services and define rules for such an orchestration. Thus, ActiveBPEL provides a Web service interface to each BPEL process that it executes. This interface is used to start a particular process and to communicate with external Web services by following execution and orchestration rules. The communication is bidirectional, i.e. ther is outgoing and incoming communication. In the case of outgoing communication the engine contacts an external Web service, invokes a particular functionality of that service and passes all the necessary parameters. On the other hand, in the case of incoming communication the engine stops the execution of the process and waits until an external service contacts the process. Depending on the parameters that are submitted by an external service and the rules defined by the process the engine decides how to proceed with the execution of the process.

3.1. Worklist Manager

Generally, a BPEL process does not take into account human users of the system but works solely with distributed functionality provided by different Web services. However, in LPM human users of the system work with the worklist manager (implemented as a special Web service) that keeps track of their tasks and activities.

The worklist manager provides facilities to add activities, pass parameters for these activities (e.g. user roles, external learning resources, and similar), and uniquely identify users that need to consume these activities. On the other hand, the worklist manager contacts the BPEL engine whenever a user has finished with a particular activity, thus signaling to the engine to continue with the execution of the process.

To support the interaction with users the worklist manager has another bidirectional communication channel. Basically, the worklist manager communicates with an integrated user interface adding new activities and listening to a notification from the user that a particular activity has been completed. Currently, this communication channel is implemented by means of links incorporated into the integrated user interface which users need to follow. For example, when users finish with an activity they are supposed to click on a so-called "Finalize" link. The corresponding HTTP request invokes a server-side functionality that passes the user and activity data to the worklist manager.

The manager marks then the activity as completed and subsequently contacts the BPEL engine. The engine might answer in one of the following ways:

- It provides a new activity.
- It sends a message that there are currently no new activities but the process is still running, i.e. the user need to check later if there are any new activities.
- It notifies the manager that the process has been completed.

After the manager receives the answer from the engine it sends an HTTP response to the LPM user interface and presents the engine response to the user.

3.2. E-Learning Services

In addition to the worklist manager the BPEL engine communicates also with Web services that expose the functionality of an E-Learning system. Currently, integration with WBT-Master (http://coronet.iicm.edu/) has been implemented. Thus, a number of Web services have been developed offering an interface for communication with WBT-Master.

All WBT-Master Web services are SOAP-based Web services that act only as simple proxies to the WBT-Master functionality. Here is a partial list of such Web services:

- Services for login/logout mechanism. These allow a so-called single-sign on procedure for LPM and WBT-Master and are therefore important to support the integrated user interface.
- Service for retrieving learning resources from WBT-Master. This service is important for supporting a simple reading activity in a learning process.
- Service for uploading learning resources onto WBT-Master. This service is important for writing, uploading, or discussion activity.
- Services for retrieving tests from WBT-Master, submitting test answers by the students, retrieving test answers and marking them by the teachers, submitting and retrieving test results.

Typically, whenever the worklist manager notifies the BPEL engine that a particular activity has been finished the engine communicates with a certain WBT-Master service and gets in this way the data needed to continue with the execution of the process.

For example, the sample learning process contains the test activity. When a student finishes the test, the teacher obtains a test marking activity. To collect the data needed for that activity (i.e. test answers) the engine communicates with the corresponding WBT-Master service. Consequently, when the teacher finishes with the reviewing of the test answers the test results are submitted to WBT-Master via a corresponding service. Lastly, before the BPEL engine decides what is the next activity for the student the engine contacts a WBT-Master service to retrieve the test results for that student. Once when the engine has that information it can evaluate the rule defined in the process and decide on the next activity for the student.

3.3. Learning Processes Definition Module

Obviously, BPEL specification and BPEL processes are technically very complex. Thus, it is impossible for non-technical users of the system to define such BPEL processes. Therefore a number of BPEL templates has been prepared that reflect typical collaborative learning processes. A simple graphical user interface for the teachers has been prepared where only parameters for single learning activities need to be defined in order to obtain an instance of a collaborative learning process.

However, in certain cases such templates are not flexible enough and the teachers need a possibility to define a new collaborative learning process from scratch. For that purpose a simple XML application has been developed. A particular XML document describes a learning procedure only in terms of a pedagogical vocabulary by defining a number of learning activities and parameters pedagogically relevant to these activities.

To obtain a complete BPEL process such pedagogical XML-based learning procedures are transformed onto a BPEL files using XSLT technology. Moreover, to ensure the extensibility of the pedagogical vocabulary XSLT transformations can be easily extended by adding a new type of a learning activity together with a corresponding BPEL output.

4. Conclusion

Currently, the LPM system is still in testing and evaluation phase. The results of the first tests with students at University of Technology Graz have been very positive.

However, implementation and configuration of the LPM system has been related with a number of technical difficulties. The majority of these problems are caused by:

- Technical complexity behind BPEL specification.
- Tight coupling of SOAP-based Web services introduced through remote procedure invocation architecture these services are based on.

One direction for the future work will be to investigate alternative possibilities for implementing Web services. For example, Representational State Transfer (REST) style Web services are one of the most promising architectural solutions in this field.

5. References

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