# An Analysis of Application of Business Process Management Technology in E-Learning Systems

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**Abstract: Generally, the current E-Learning systems concentrate on individual learning tasks rather than on a learning process. However, learning situations as we observed them in practice are generally process-oriented. Thus, support for such process-oriented learning situations can be seen as one of the most important requirements for the next generation of E-Learning systems. Fulfilling such a requirement raises a number of technical issues such as management of learning processes including their modeling, design and execution as well as the automation of such processes. This paper discusses possibilities for applying Business Process Management in E-Learning systems for that purpose. This discussion is summarized as a list of requirements on both Business Process Management systems and E-Learning systems for realization of such an application. Finally, the paper sketches shortly some implementation issues that can arise in practice.**

## 1. Introduction

Currently, the most popular E-Learning systems, such as WebCT (WebCT, 2005) or Blackboard (Blackboard, 2005) support only individual learning tasks rather than the learning process. When using such systems learners typically access a learning course published in the system, navigate through that learning course and learn by reading the learning resources prepared by the teacher. Additionally, a discussion forum associated with the course might be used for discussion of issues relevant to the course.

However, in numerous research and commercial E-Learning projects in both academic and industry environment we have observed learning situations that are not task-oriented (Helic, Maurer, and Scerbakov, 2005). Rather those learning situations are process-oriented and generally include a number of related learning tasks connected into a coherent and sound pedagogical entity. For example, a typical learning situation in the software industry reflects a well-known project-oriented pedagogical strategy (Thomas, 2000). According to this strategy learners acquire new knowledge by doing a practical work in a real-life software project. Such a practical work includes a number of learning tasks such as reading about the principles of project management, reading about a software development method, executing the steps of the applied software development method (this might include writing software design documents in collaboration with the peers, programming tasks or reviewing the source code of other team members) or reflecting on the gained learning experiences by writing a project report.

Thus, a learning process might be seen as a real-life instantiation of a particular pedagogical strategy that generally consists of:

- A set of related learning tasks that are executed according to the rules of the pedagogical strategy in question. By executing these learning tasks learners achieve a certain learning goal.
- A number of participants each of them having a particular role within the process (e.g. learners, tutors or teachers).

- A number of learning resources needed to achieve the learning goal.
- A number of interactive system tools that support participants in their individual work but also in their communication and collaboration with other participants of the process.

Apart from their task-orientation another important characteristic of the current E-Learning systems is a static nature of the learning environment that they offer. In other words, neither a published learning course nor any of its components changes during a particular learning session. Basically, such courses are generic learning entities that need to fit a wide number of different learning situations and cannot take into account specific issues of a particular situation. However, this "one size fits all" approach leads to many problems in situations where learners differ in their learning styles, preferences or knowledge level. In order to tackle such problems numerous research efforts dealing with so-called adaptive features in E-Learning systems have been started. Such efforts concentrate on supporting automatic adjustment of a learning course and its components to the characteristics of an individual learner. Nevertheless, these efforts still concentrate on individual learning tasks and do not take into account the learning process as a whole. Moreover, there are still no implementations of such features in major commercial E-Learning systems.

However, learning processes as we have observed them in practice are very dynamic entities. Usually, all of the process components are very often altered as the result of the learning progress. For example, in the above mentioned project-oriented learning situation in the software industry some of the learning tasks closely reflect the applied software development method. Thus, whenever this software development method is changed the learning tasks in question need to be updated as well. Similarly, the learning resources are very often updated, replaced, deleted or added as a result of new trends and insights in the subject field or as a consequence of the current learning situation. Last but not least, the system tools that support the learning process might be replaced too. For example, in an important learning situation within the project-oriented learning process (e.g. designing the software architecture of a software system) synchronous communication between team members might be more appropriate than prescribed asynchronous communication. To support such a modification the attached discussion forum might be replaced with an instant messaging tool.

Obviously, because of such a dynamic nature of a learning process we can speak about the learning process lifecycle. From our experience, this lifecycle consists from the following three phases:

- Modeling phase, where a particular learning process is modeled with all of its components.
- Learning phase, where a learning process is executed.
- Observation and improvement phase, where a learning process is monitored, analyzed and subsequently improved to optimally fit a particular learning situation.

Since the current E-Learning systems do not deal with learning processes per se, the learning process lifecycle can be supported by those systems only partially. For example, teachers design learning courses but can not define the pedagogical rules that will govern the learning process. Rather the teachers need to monitor the learners and impose the pedagogical rules themselves in order to lead the learners to a particular learning goal. Moreover, it is very difficult to improve such a process for subsequent executions since modifications can be only made at the level of the learning courses but not at the level of the process itself. Basically, a subsequent execution of the process requires that the teachers repeat their process monitoring work since there is no possibility for modeling and managing of processes.

In this paper an analysis of suitability of Business Process Management (BPM) technology to support management of learning processes including their modeling, design and execution as well as the automation of such processes in an E-Learning environment is presented. The next section introduces BPM as well as the notion of a business process and the business process lifecycle and presents how these can be mapped onto a learning process and the learning process lifecycle respectively. The third section discusses the requirements on both BPM systems and E-Learning systems to facilitate an application of BPM in E-Learning systems. In the fourth section a number of implementation issues are addressed. Finally, some conclusion remarks are given.

## 2. Business Process Management Technology

Business Process Management (BPM) is a novel technology that evolved from the workflow technology by its convergence with Enterprise Application Integration (EAI) and the Web technology. The

Workflow Management Coalition (WfMC) defines workflow 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 (Hollingsworth, 1995). 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.

The first generation of workflow management systems was developed in the 1990s. Most of these systems were implemented as standalone systems. However, the huge expansion of the Web in the past decade influenced the way how different organizations execute their business processes. Nowadays, in many organizations business processes are typically Web-oriented. To cope with that situation the workflow technology embraced different Web technologies and became in this way a Web-based technology. During this period experiences and principles from the EAI field and the core Web technologies were slowly adopted by the workflow technology. For example, the advancements in system and application integration from EAI, as well as generic communication protocols, data and document exchange formats from the Web influenced developments in the workflow field to a large extent.

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 that operate 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 workflow. This current state of the workflow technology is commonly referred to as BPM. Thus, BPM might be seen as workflow in a Web environment that is based on the open Web standards such as XML and Web services (Hollingsworth, 2004).

BPM is founded on the principle that a business process is a subject to change. Therefore, BPM deals with a so-called business process lifecycle model. This lifecycle model consists of three phases (Hollingsworth, 2004):

- Model and design phase, where first a conceptual model of a business process is defined. Such a model includes participants and their roles within a business process, as well as actions, tasks, activities and procedural rules that govern the process. At the second step this conceptual model is mapped onto an executable model which specifies run-time process behaviour including specification of services, their interfaces and execution flow.
- Deployment and execution phase, where a particular business process is deployed and executed within a BPM runtime engine.
- Analysis and improvement phase, where a running business process is observed, analysed and subsequently improved to optimally suit a business goal.

Basically, we can identify here a one-to-one mapping between the learning process lifecycle and the business process lifecycle. They both consist of three phases that deal with process modeling, process execution and process improvement respectively. Moreover, a similar one-to-one mapping exists between a learning process and a business process. For example, both a business process and a learning process deal with tasks and activities structured in a certain way and executed by following a set of procedural rules, i.e. business rules or pedagogical rules respectively. Further, participants of both processes can be either humans or software systems. Generally, participating software systems are Web-based systems in both cases. On the other hand, in both processes human participants by following the process rules attempt to achieve a certain goal, namely a business or a learning goal. Finally, in both cases we are interested in the automation of a process, in whole or part, by means of software.

Therefore, BPM and its integration in the context of E-Learning systems, as well as reuse of the experiences, practices and principles from BPM seems to be a natural technological choice for management of a learning process and the learning process lifecycle in E-Learning systems.

## 3. Requirements for Application of BPM in E-Learning Systems

A number of requirements for a successful application of BPM in E-Learning systems can be identified. These requirements must cover both the technical aspects as well as the user aspects of such application. Additionally, in order to support efficient management of learning processes the whole learning process lifecycle with all of its phases needs to be taken into account by these requirements.

Let us first investigate user requirements by looking through all three phases of the learning process lifecycle. Firstly, in the model and design phase we are interested in supporting users during authoring of a learning process. Requirements for an authoring tool can be defined as follows:

- Usually, in BPM a business process is defined using a graphical notation, such as standardized Business Process Modeling Notation (BPMN). A similar notation should be taken as the basis for the learning process authoring tool. Thus, the tool must support a graphical notation for defining a learning process including learning tasks, activities, procedural pedagogical rules, participants and their roles.
- Since notations such as BPMN are meta-modeling notations, i.e. such notations introduce only abstract modeling elements such as task, activity, participant, role or rule; a pedagogy-specific vocabulary based on these abstract elements should be constructed. For example, learning tasks such as reading, writing, testing or reflecting might be introduced. Similarly, participant roles such as teacher, tutor, mentor or learner should also become a part of this pedagogical vocabulary.
- The authoring tool should support component-based (i.e. hierarchical) approach to modeling of learning tasks to enable reuse of process designs. It should be possible to model a learning task as a composite task that connects a number of other tasks into a learning sub-process. Such a learning sub-process may be reused in a wide range of learning processes as a single task. For example, a quite common learning task in the above mentioned project-oriented learning process is a so-called collaborative writing task. This task is a rather complex task that comprises a number of other simpler learning tasks. Usually, collaborative writing involves learners firstly in reading an introductory document written by the teacher. In the next step the learners write a particular document in collaboration by following the guidelines provided by the teacher. During their writing task learners also discuss all open issues with their peers and the teacher. Since this learning task is repeated many times in different contexts during the project-oriented learning process it would be meaningful to model it as a learning sub-process and reuse it throughout the process. For instance, each time when the learners need to write a specific project-related document (e.g. the software architecture document, the software design document or the software documentation) they are involved in such a collaborative writing sub-process.
- Finally, the tool should support a so-called template-based authoring approach. It should be possible to manage a library of predefined templates of commonly used learning processes. Subsequently, those templates can be customized to match the current learning situation. For example, the above mentioned project-oriented learning process might be defined as a template. This template can be adjusted to reflect certain learning situations such as changes in the software development method. Furthermore, process templates should be also used to instantiate a particular learning environment in regard to selection of concrete learning resources. Thus, the project-oriented process template should only include a definition of activities, tasks, rules or participants without referring to particular learning resources. The learning resources are then selected and associated with different tasks, activities and roles during the instantiation phase.

User requirements for the second phase, i.e. the deployment and execution phase comprise the following items:

- Deployment of a learning process should be automatic and integrated within the authoring tool.
- The so-called worklist (i.e. the list of tasks that a particular participant needs to accomplish) should be integrated into the existing user interface of an E-Learning system. User interface of the worklist could follow the hypertext interface paradigm, e.g. different tasks might be represented as hyperlinks. By clicking on a particular task-related link users access the associated learning environment, i.e. a system tool associated with the task and all the learning resources needed to accomplish the task.

Finally, user requirements for the last phase, i.e. the analysis and improvement phase can be summarized as follows:

- The system should support the teacher in monitoring of the learning progress and collecting information for improvement of a learning process. At the next step, the authoring tool can be used to make necessary changes and improvements by creating a new instantiation of a learning process. Additionally, the system should provide facilities for users to provide feedback on a learning process and make improvement suggestions.

- On-the-fly authoring, i.e. editing of a running learning process to provide an immediate response to the current learning situation is desirable but would introduce another level of technical complexity in the run-time BPM engine (this would require execution of so-called ad-hoc workflows with generic tasks that are bound to concrete tasks at run-time). Nevertheless, possibilities for implementing such a feature should be investigated.

Apart from user requirements a number of technical requirements for both BPM systems and E-Learning systems can be identified. These requirements can be also classified according to the phase of the learning process lifecycle that they address. In the model and design phase we can identify the following requirements:

- Process models created by means of the graphical notation should be automatically mapped onto executable models that can be executed by a BPM run-time engine. Currently, most BPM run-time engines work with executable models defined in Business Process Execution Language for Web Services (BPEL4WS). There exists a standardized mapping procedure from BPMN onto BPEL4WS that should be used to support automatic mapping.

In the deployment and execution phase the following requirements should be satisfied:

- Executable elements in BPEL4WS execution models are Web services. Therefore, in order to support a seamless integration of a BPEL4WS engine and an E-Learning system, E-Learning functionality should be exposed as a collection of Web services. Additionally, a specification of interfaces of such Web services should be defined. For example, suppose that a learning process requires upload functionality to store user contributions. The E-Learning system offers upload functionality by means of a standard HyperText Transfer Protocol (HTTP) method. To integrate it with the BPEL4WS engine upload functionality must be made available through a Web service with a clearly specified interface. Typically, the created Web service will operate only as a mediator between the specified interface and the concrete interface of the E-Learning system.
- To facilitate automatic mapping between process models and executable models the specification of Web services and their interfaces must take into account the pedagogical vocabulary used in the authoring tool. For example, each learning task defined in the vocabulary should be supported either by a single Web service or by a combination of Web services.

In the analysis and improvement phase the following technical requirements can be identified:

- On-the-fly authoring requires execution of ad-hoc workflows. Generally, such workflows include generic tasks that are bound to concrete tasks at run-time depending on the execution flow. The only way to support such requirement within the context of BPEL4WS would be to use so-called Semantic Web Services. Semantic Web Services use another (semantic) level of interface descriptions by applying Semantic Web technologies such as Web Ontology Language (OWL). Using these descriptions a BPM engine can decide which service is a most suitable one for the execution of a generic task and bind that service at run-time. Currently, no BPM engine supports such a feature. Thus, fulfilling this requirement represents a rather challenging technical task.

## 4. Implementation Issues

We plan to make the first implementation steps with the WBT-Master E-Learning system (WBT-Master, 2005). The system concentrates on collaborative aspects of E-Learning by offering tools that support collaborative writing, brainstorming, synchronous and asynchronous discussion, structured discussion or voting.

As a BPM runtime engine we plan to use the IBM Business Process Execution Language for Web Services Java Runtime (BPWS4J). For each business process this runtime engine takes a BPEL4WS document which describes the process and WSDL documents which describe the services that the process may invoke during its execution. After deployment the process ís made available to outside consumers through a Simple Object Access Protocol (SOAP) interface. As a modeling tool we plan to use any standard-aware tool that supports BPMN notation such as ILOG JViews.

Basically, there are three main implementation areas:

- Development of the pedagogical vocabulary and a number of templates based on that vocabulary. These templates will support users in modeling of learning processes.

- Development of mapping strategy between the pedagogical vocabulary and WBT-Master functionality. Additionally, WBT-Master functionality should be exposed in the form of Web services to facilitate integration of that functionality with the BPWS4J runtime engine.
- Integration of worklists managed by the BPWS4J engine into the user interface of WBT-Master.

The pedagogical vocabulary will be developed based on our experiences with WBT-Master in the field of collaborative learning strategies. The first step here would be to identify a number of basic collaborative learning tasks. At the next step, a number of components, i.e. learning sub-processes that can be reused in a number of different processes should be identified. Finally, a number of process templates (e.g. reflecting collaborative learning strategies) should be created.

In the second implementation area, a number of Web services that act as mediators between the BPWS4J runtime engine and WBT-Master will be implemented. Those services will provide SOAP interface for accessing WBT-Master functionality. Additionally, WSDL descriptions of interfaces to those services should be developed to facilitate their automatic integration with the BPM engine.

Finally, in the third area we plan to use a so-called virtual learning room tool from WBT-Master. This tool represents a single-point entry to a collection of other system tools and learning resources needed for a particular learning session. Thus, it provides a static learning environment that can be used as the starting point for introduction of dynamic aspects of a leaning process. For instance, user interface for worklist of a running learning process can be integrated into the virtual learning room. As users progress with the learning process the virtual room is dynamically customized to include the tools and learning resources which are important for the learning task at hand. The implementation of such a worklist will require a server-side module that will communicate via SOAP with the BPWS4J engine and integrate the responses from the engine into the virtual room.

## 5. Conclusion

In this paper we argued that one possible way to tackle the technical issues of management and automation of learning processes in E-Learning systems is by reusing the technological solutions, experiences and principles for managing of business processes from Business Process Management. Since there is a strong similarity between a learning process and a business process in both user aspects as well as technical aspects we believe that applying BPM to management of learning processes can prove efficient, easy to develop and maintain, as well as powerful enough to support a wide range of common learning situations in E-Learning systems.

## References


Blackboard, *Bb*, 2005, http://www.blackboard.com

Helic D., Maurer H., Scerbakov N.: *A Didactics Aware Approach to Knowledge Transfer in Web-based Education*, In Claude Ghaoui, Mitu Jain, Vivek Bannore, Lakhmi Jain (Editors), Studies in Fuzziness and Soft Computing, Volume 178/2005, Chapter 9, pages 233-260, Publisher: Springer-Verlag GmbH, 2005.

Hollingsworth D., *The Workflow Reference Model*, The Workflow Management Coalition Specification, 1995, http://www.wfmc.org/standards/docs/tc003v11.pdf

Hollingsworth D., *The Workflow Reference Model: 10 Years On*, In Workflow Handbook 2004, Publisher: The WfMC, 2004, http://www.wfmc.org/standards/docs/Ref_Model_10_years_on_Hollingsworth.pdf

Thomas, J.W.: A *Review of Research on Project-based Learning*, Ph.D. Thesis, 2000

WebCT, *Learning Without Limits*, 2005, http://www.webct.com

WBT-Master, 2005, http://coronet.iicm.edu