CAPTURING AND MONITORING OF LEARNING PROCESS THROUGH A BUSINESS PROCESS MANAGEMENT (BPM) FRAMEWORK

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Abstract: In recent years, e-Learning systems have significantly impacted the way that we learn within universities, both in providing self-learning support and flexibility of course delivery. Virtual Learning Environments (VLEs) such as Moodle help facilitate the management of educational courses for students, in particular by helping lecturers and students with course administration. However, issues still remain; in particular e-learning environments provide a *one size fits all* approach to the learning process through the course materials - each student must follow the same learning path, regardless of their *a priori* knowledge, learning requirements or learning disability. Many commercial VLEs allow course writers to build courses as groups of lessons, but it is currently not possible to monitor the learning process of individual learners or learning groups through the course material in real-time. In order to solve the issues of a *one size fits all* approach; this paper discusses the development of a system that develops an adaptive learning process management system, using the concept of Service Oriented Architecture (SOA) and Business Process Management (BPM). This system allows the course-writer to monitor the learning process of the learners in real-time and manually adapts the learning path or course materials. The paper also discusses possible future extensions to the work that would allow for the automatic adaptation of the learning path to meet an individual learner's needs. The paper concludes by discussing the benefits and limitations of our BPM implementation and discusses future extensions to allow for the automatic adaptation of learner's learning path.

Keywords: Service Oriented Architecture, Business Process Management, Business Process Execution Language, Virtual Learning Environment

1. INTRODUCTION

The ubiquitous nature of the Internet/Web has enabled e-learning to be a fundamental tool for training and development, and it has altered the availability and the way that we access our learning materials. In the academic environment, e-learning is becoming vital for distance education, and when e-learning is seen as complementary to the classroom environment it can help to strengthen the traditional pedagogy. While an education pedagogical structure is paramount in established educational systems (formal or informal), the role of technology should be seen as a platform to realising such pedagogy. Compromising education pedagogical structure due to technological deficit would be detrimental to the expected learning outcomes, even though it is arguable that technology can influence the course or shape of such pedagogy. Modelling traditional and distance education pedagogical structure can be challenging because of the variety of choice of appropriate technologies.

A Virtual Learning Environment (VLE) is a software system that helps to bring the implementation of e-learning to realisation. It is a set of teaching and learning tools designed to enhance students' learning experiences through the use of computer resources and the Internet within the learning process. VLEs were originally designed for distant participants (learners & teachers) but they are not restricted to distance education (Dillenbourg, 2000). In fact, research shows that VLEs based on Web 2.0 technologies have the potential to: stimulate active participation and individual production of knowledge; support the performance of formal and informal web-based learning activities; take the best out of the "collective intelligence" in order to create learning experiences; and, support the dynamics and openness of a learning process (Malinka, Anguelina, 2009). One of the limitations of the existing VLEs (e.g. Blackboard, Moodle etc) to drive new education approaches is that e-learning environments provide a *one size fits all* approach to the learning process through the course materials - each student must follow the same learning path, regardless of their *a priori* knowledge, learning requirements or learning disability. There is a need to extend current VLE functionality beyond this limitation if VLEs are to continue to play a significant role in the educational systems of the future.

Designing and developing a VLE that will significantly address the issues of *one size fit all* is important, therefore such a VLE needs to be designed and developed as a system where:

- It seamlessly integrates heterogeneous technologies and multiple pedagogical approaches.
- Flexible formal and informal learning flow are allowed to drive a new education approaches.
- Learners learning pathway can be tailored to their profile and dynamically adapted to their run-time behaviour.

This paper presents the technological framework to deliver a VLE system that allows customised learning paths through course materials to be created, delivered and monitored. This gives the course-writer the ability to analyse, manage and change the learning pathways in response to the monitored data. The course-writer can also manually adapt the course materials in response to monitored data.

Figure 1 illustrates an overview of the proposed VLE that allows monitoring of an adaptive learning process. It depicts how customised learning path can be created, depending on a learner's unique need. A learner logs into the VLE to work through course material, the requisition component checks for outstanding pre-requisite or special needs that might impede the learning process before any topic is displayed. Mastery level of each topic is examined and if each topic is not passed the learner is auto-routed through the path manager to additional external resources. The course-writer can login to the same system to see a dashboard, which allows for individual or aggregate learners' progress through the materials to be monitored.

2. CURRENT VIRTUAL LEARNING ENVIRONMENT SOLUTIONS

Following the emergence of the Internet, education communities have witnessed the emergence of software-aided tools that aim to support learning and teaching activities through the Internet (O'Leary, 2002). VLEs are software systems designed to facilitate teachers in the management of educational courses for their students, especially by helping teachers and learners with course administration. The principal components of a VLE package include: curriculum mapping; student tracking; online support for teachers and students; electronic communication; and, internet links to outside curriculum resources. The

most popular VLEs currently available are Blackboard, WebCT, Moodle, Learning Activity Management System (LAMS), SAKAI and many others. Blackboard and WebCT are two leading commercial systems that are used worldwide. SAKAI and Moodle are open source VLEs that are increasingly popular (Weller, 2006).

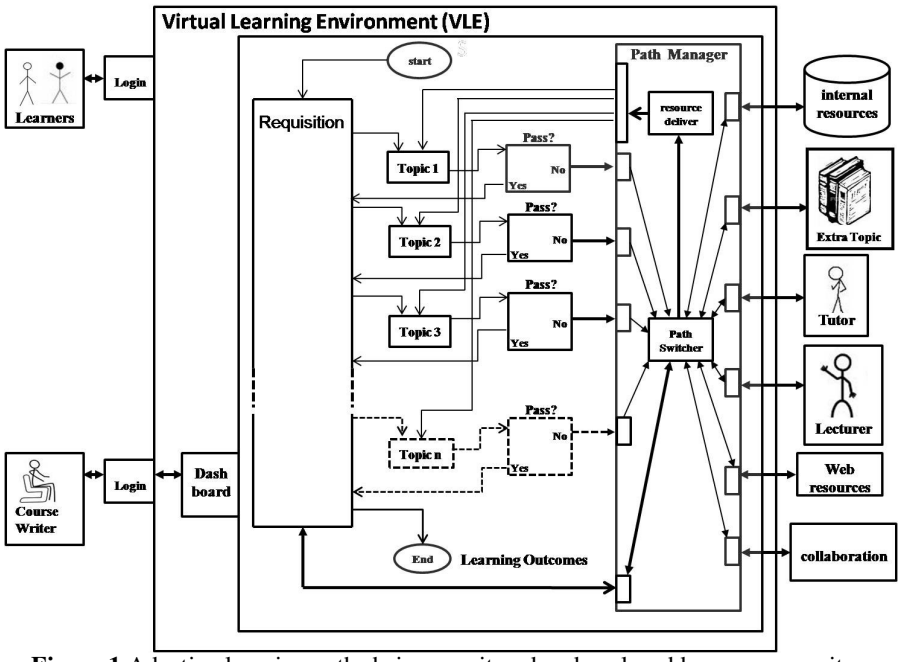


Figure 1 Adaptive learning paths being monitored and analysed by a course-writer.

2.1.1. Commercial VLEs

Commercial VLE products, which form the vast majority of VLEs in use within further and higher education, are generally characterised as 'content-centred', rather than being aimed at encouraging the active learning embodied in constructivist pedagogies (Dunn, S. 2003). The ever-increasing licensing fee is one of the factors still inhibiting the widespread adoption of commercial VLEs. Commercial VLEs are ready-made off the shelf products written externally, which offer significant initial savings in procurement and maintenance, but institutions fear future changes to the product will not be under their control. The largest market share belongs to Blackboard and WebCT, both of whom do not capture learning paths; consequently, the learning process cannot be monitored in real-time.

2.1.2. Open source VLEs

It has been argued that open-source software can help in saving the ever-increasing licensing fee of any commercial provider such as Blackboard (Wheeler, 2004). Additionally, open-source VLE open up opportunities to further develop the VLE to meet specific needs of an institution or a group of institutions. However, open source VLEs can become compromising with inadequate documentation, less functional features and numerous bugs - commercial systems are often seen as a "safer" option (Young, 2004). There is a natural affinity between the open source and academic communities, with the process of contributing code compared with that of the academic review process (Bergquist and Ljungberg, 2001). Also, many open source contributors are employed in education and many such projects begin as educational projects. For example, Moodle began as part of founder's Martin Dougiamas' Ph.D. Therefore, it would make sense that in the area of VLEs, if a successful open source solution could be found (Weller, 2006).

LAMS is an integrated system for authoring, running and monitoring Learning Designs (Dalziel 2006). It is developed using Extensible Markup Language (XML), HyperText Markup Language (HTML), Java, Flash technologies. A functioning version of LAMS was presented at the Valkenburg group meeting in February 2003, based on the "What is Greatness?" use case. At this presentation, a number of challenges for Instructional Management Systems Learning Design (IMS LD) arising from LAMS development were noted. Some of these challenges were:

- More detailed concepts of sequencing within "Acts", including within-Act multi-learner synchronisation, and Simple Sequencing
- More development of how a teacher monitors and approves actions in real-time during a complex, multi-task activity sequence." (Dalziel 2006)

LAMS is inspired by, and heavily based on IMS LD (Dalziel, J. 2003), therefore, it is inherently faced with the challenges outlined above. The "Think globally, act locally" approach is lacking within existing VLEs. Thinking globally is to define and expect the same learning outcomes through well designed course materials; however, acting locally is to expect that each learner is different and consequently requires a mechanism for each learner to uniquely meander his/her way to achieve the same learning outcomes. A single learning path for all learners in LAMS or any other VLEs is tantamount to "Think globally, act globally" i.e. every learner must act in the same way to achieve the same thing. This replicates the same issues of *one size fit all* approach. Since the learning path in LAMS is predetermined, what is left to monitor is the learning process through a sequence of learning activities. The desired "learning outcomes", without an adaptive instructional design, is reduced to the "learning". LAMS may therefore be seen as the first in a potentially extensive range of specialised learning design editors that provides easy to use high-level tools for a particular pedagogic approach. Such tools do not necessarily aspire to generating all possible pedagogic structures, but rather to providing effective solutions for the needs of practitioners (Griffiths, 2005).

The drawbacks of both the commercial and open source VLEs, when addressed with the conceptual framework of certain open source technologies, set a good foundation for the development of a future VLE. This paper presents a Business Process Management (BPM) concept as the conceptual framework for capturing and monitoring the foot print of an adaptive learning process.

3. BUSINESS PROCESS MANAGEMENT (BPM) CONCEPTS

BPM refers to: aligning processes with the organisation's strategic goals; designing and implementing process architectures; establishing process measurement systems that are aligned with organisational goals; and, educating and organising managers to manage processes effectively (Bosilj-Vuksic, *et al*, 2005). It ensures continued improvement of business performance by managing the processes and their components: organizational structure, policies, business rules, regulations, human resources, and ICT. The term is occasionally used to refer to various automation efforts such as workflow systems. BPM enables automation of business processes by separating process logic from the applications that run them; managing relationships among process participants; integrating internal and external process resources; and, monitoring process performance (Bosilj-Vuksic, *et al*, 2005). Figure 2 illustrates the life cycle of a BPM system right from the inception of a business concept. A business concept is: model in a business modeller; implemented and deployed in a business run-time engine; monitored in a business monitoring activity system (e.g.

dashboard); and, analysis/optimisation is performed based on feedback for continuous improvements.

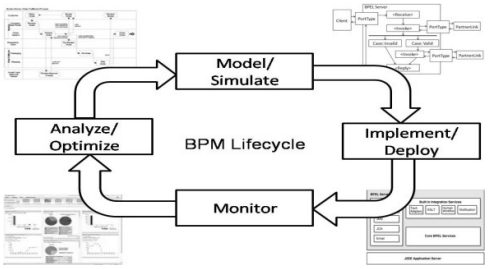


Figure 2 End-to-end life cycle of BPM

3.1. BPM-based VLE

The choice of technological model of any VLE can potentially determine the extent to which such a VLE can best serve to implement any educational pedagogy. However, the ability to capture and monitor an adaptive learning path within an adaptive workflow management system would require a much more advanced technology. For the orchestration of any flexible and adaptive learning process, BPM technologies would be *sine qua non* to its implementation in the 21st century because BPM technologies are the official standards for any workflow management system. Workflow to this point has always been about software, computer or machine interactions, but BPM helps to introduce human interaction into a workflow model. This is one of the greatest advantages of BPM as human intervention is routinely expected in implementing a hands-on adaptive learning process. This paper employs and explores the particular BPM technologies that enable the automation and monitoring the foot print of an adaptive learning process.

3.2. BPM Technologies for Learning Process managements

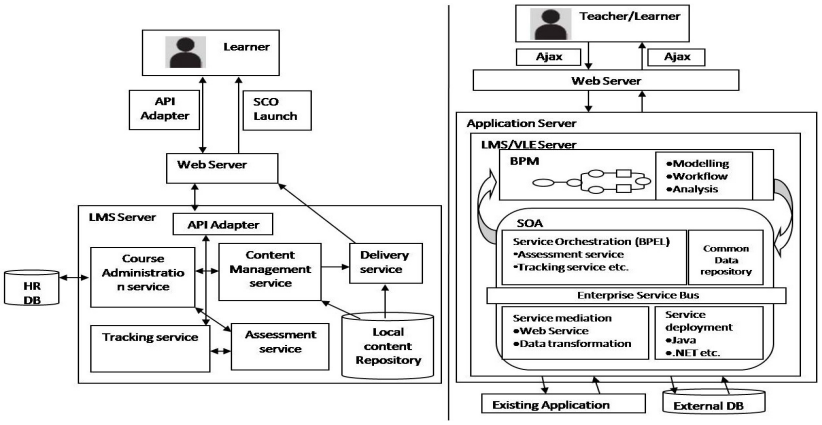
BPM technologies are employed to implement the learning processes through course materials by orchestrating interactions between learning services (learning activities and learning objects exposed as a web services) within the proposed BPM-based VLE. The paper focuses on the use of the following popular BPM technologies;

- Business Process Modelling Notation (BPMN) – This is a core enabler of BPM. BPMN is a standardised graphical notation for drawing/modelling business processes in a workflow system. BPMN has been developed to enable a business user to develop readily understandable graphical representations of business processes. In the proposed BPM-based VLE, BPMN is used to model learning processes/activities. The course-writer would in effect chart the available paths through the course material and would describe each interaction with the course material/tutors etc.
- Business Process Execution Language (BPEL) – BPEL allows composition of web services and it is therefore the top-down approach to Service Oriented Architecture (SOA). It's a language that specifies the behavior of business processes (modeled in BPMN) between Web services and as Web services. It is expressed in XML file that can be read and executed by any conformant BPEL engine. In effect this technology would allow the BPMN chart that is created by the course-tutor to be 'compiled' into the software system that forms the learning part of the VLE.

Service-oriented Architecture (SOA) is an architectural concept that relies on loosely-coupled software agents to perform specified tasks. Although SOA is not a BPM technology, both technological concepts are complementary. Web services are the primary technology for implementing SOAs, composition of Web services is needed to realise the vision of SOAs. BPEL is the primary industry standard for composing Web services (service can be

implemented in any language). Learning activities, learning objects and external recourses are exposed as web services; these in turn are orchestrated using BPEL. The recent release of open-source systems like JBoss jBPM, Intalio, Spagic etc have made traditionally expensive BPM tools available to the academic community. This makes business process orchestration faster, cheaper and monitoring the execution of the business processes so that managers can analyse and change the business process in response to monitored data.

4. IMPLEMENTATION



(a) (b)

Figure 3 (a) An illustration of a SCORM compliant VLE model (b) An illustration of the proposed BPM-based VLE**.**

Figure 3(a), illustrates a Sharable Content Object Reference Model (SCORM) compliant VLE model**.** Figure 3(b) illustrates the proposed BPM-Based VLE architecture diagram. Because BPEL is a web services orchestration language, all learning components (Modules, learning stage, learning requisition, topics, questions, marking questions, mastery level etc.) are exposed as web services.

4.1. Mapping a Learning Process with BPMN

BPM technologies are an important part of the implementation of an adaptive leaning process that can be monitored. In this paper the Eclipse BPMN Modeller is used because it allows all stakeholders to get involved in contributing to how the future learning process should take shape. IT specialists may or may not even surface at this stage, as the analysis of a learning process in the BPMN diagram as shown Figure 4 is a process-oriented architecture. In the BPMN diagram (expanded in Figure 5a-e below), blue components indicate learning components invoked; white components indicate the internal states of the process and the gold components indicate the human (learner) involvement/task.

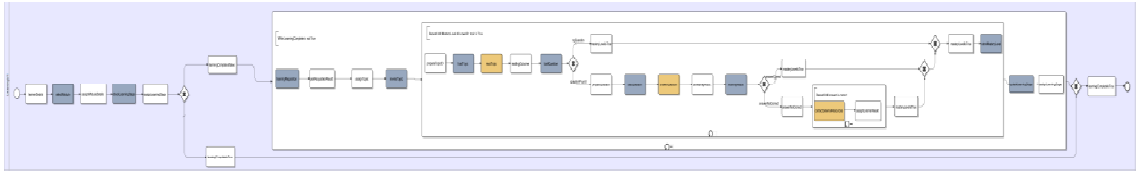


Figure 4 BPMN diagram of a Learning Process

The segments of the BPMN diagram are further explained in Figure 5(a)-(g).

Figure 5(a) Learner's details associated with a module and learning stage.

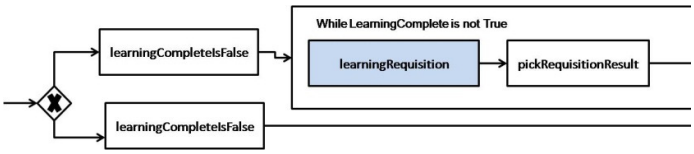


Figure 5(b) If learning is not complete, request for learning is made on learner's behalf.

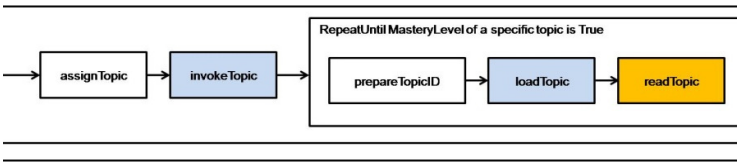


Figure 5(c) Learner revived a topic until a mastery level is attained on the topic.

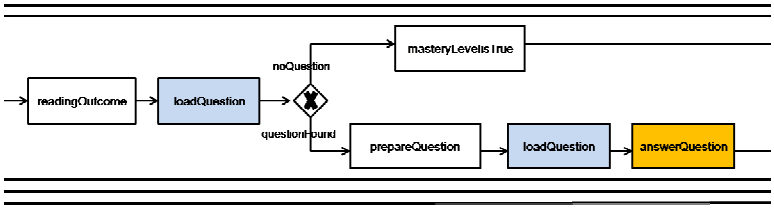


Figure 5(d) Mastery level is tested through available questions for the topic.

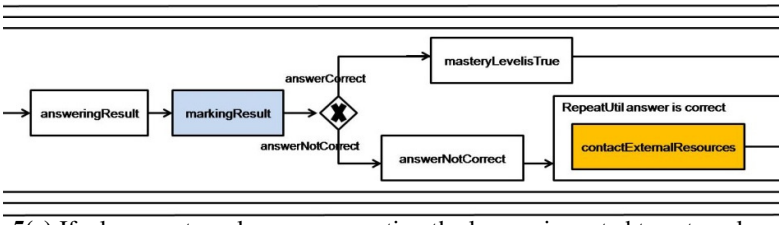


Figure 5(e) If a learner struggles over a question the learner is routed to external supports.

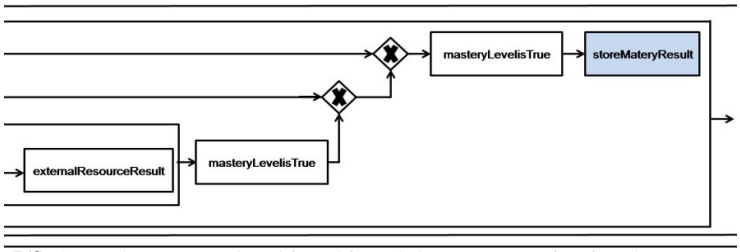


Figure 5(f) Once the mastery level is achieved the system maintains the mastery level.

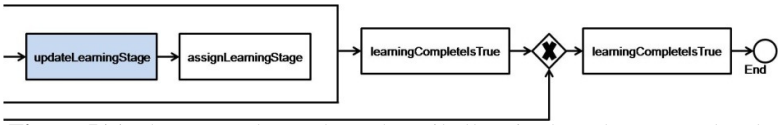


Figure 5(g) The system loops through until all topics have been completed.

4.2. Transforming Learning Process BPMN to Executable Learning Process BPEL

BPMN diagram is not executable hence the need to transform into an executable program language. In this paper the BPMN diagram in Figure 5 is transformed into BPEL. Using Eclipse SOA Tool Platform (STP) Intermediate Model (IM), the initial step involves exporting the BPMN to the IM (a "bridge" between STP editors). A half completed BPEL process is generated from the IM and the BPEL is completed with all necessary coding and

the artefacts (e.g. deployment descriptor, the BPEL web services interface etc.) needed for deployment. Figure 6 shows a fragmented diagram of the generated BPEL version of the BPMN diagram in Figure 5. The completed learning process BPEL and all its artefacts are deployed into a BPEL engine where it can be accessed by any BPEL client.

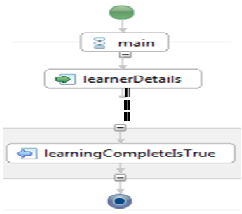


Figure 6 Fragmented BPEL version of BPMN Learning Process

4.3. Monitoring Learning Path on a Dashboard Console

While capturing the learning process is accomplished within the BPEL engine where the BPEL is running, monitoring the stages of the process when invoked by a client requires a BPM dashbaord/Business Activity Monitoring (BAM). BAM is the marriage between business integration and business intelligence. BAM provides real-time alerts based on business metrics when business processes are in need of intervention. The open-source Spagic BPM dashboard is used to monitor the deployed BPEL learning process and Figure 7 shows the chain of the deployed learning process in a BPM dashboard. Figure 8(a) shows the learning path a learner maintained to complete a learning process. Figure 8(b) shows a learner stuck at a particular stage of the learning process and this is where an internention is probably required.

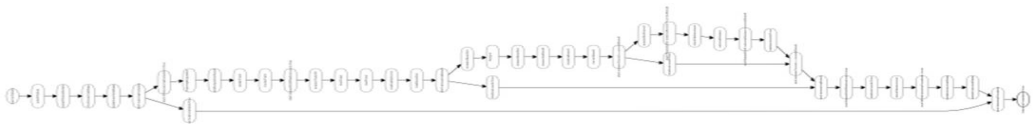


Figure 7 Chain of an un-invoked learning process.

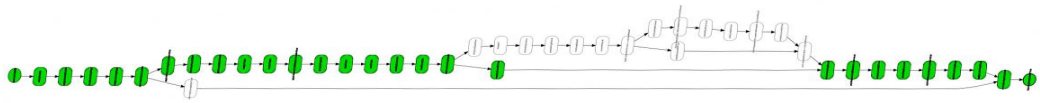


Figure 8(a) Learning path of an advancing learner captured and monitored.

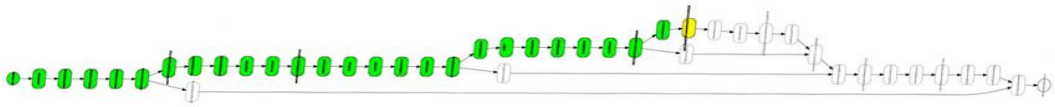


Figure 8(b) Learning path of a struggling learner captured and monitored.

5. CONCLUSION AND FUTURE WORKS

In this paper we have presented an approach to modelling, analysing, detecting and monitoring a learning process through course materials. We model and analyse the learning process in BPMN, execute semantic web services (learning activities, learning objects and external resources) orchestration with BPEL and using Spagic BPM dashboard we were able to monitor the learning process in a real-time manner. Within our approach however, are a number of assumptions. In the first case we have abstracted several areas of the composition such as learners' prior knowledge, learning requirements or learning disability. Secondly, the BPEL modelling structure for learning material is hardcoded, but needs to be generated on-

the-fly to accommodate any structure of course material. We have proposed an initial architecture, but future work will aim to provide a comprehensive and extensible workflow solution to the *one size fit all* problem by extending the BPEL4People, XForms technologies. These will also include full implementation of all areas of assumptions so as to create a more flexible and adaptive learning path in the learning process.

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