Monitoring of Learning Path for Business Process Models

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Abstract: In modern society the employees of complex organizations are under pressure to constantly improve their knowledge and skills. Novel approaches and tools to support effective and efficient workplace learning in collaborative and engaging ways are needed. On the other hand, Business Process Management (BPM) is more and more employed to support and manage the complex processes carried out within organizations. BPM can be used as well to guide workplace learning, with the advantage of naturally aligning training tasks to real tasks. We introduce a specification of learning path that maps BPM tasks and activities into sequences of learning tasks. Our learning path specification can thus be used to both drive learning sessions carried out by simulation, and to inform a monitor that can assess learner's progress. The goal is to combine work and learning in natural and effective way and use available business monitoring techniques to monitor the learning progress of the learners. In the paper we describe our specification, the e-learning platform under development, and the approach to derive monitoring rules. The approach is illustrated through a simple motivational example.

1 INTRODUCTION

In recent times, the penetration of Information and Communication Technology (ICT) in business organizations is deep and pervasive: it can be confidently stated that ICT supports every aspect of the functioning of modern organizations. As the adoption of ICT increases, the interaction between actual physical business transactions and software technologies become heavily intertwined and inter-dependent.

Several methodologies have been proposed to make the integration of ICT and work procedures easier and more efficient. One such methodology is Business Process Management (BPM) discipline (Jeston and Nelis, 2014), which helps the organizations to structure their business functions as a series of processes. BPM has matured in the last couple of decades and has penetrated many large scale organizations in their design of business processes as well as of the related software applications needed to execute the processes. Systems that are developed using BPM techniques are referred to as Business Process Management Systems (BPMS).

As the business environments become more organized and efficient due to the implementation of such methodologies, the employees of the organization are under pressure to constantly improve their performance in carrying out the business processes that they are involved in. Employees are expected to continuously gain knowledge and increase their skills: learning is no longer confined within formal courses in school or University, but happens more and more as a continuous and lifelong process.

Indeed, advanced countries see investing in employee education and qualification as a necessary condition to overcome economic crisis and support innovation. Workplaces are now considered as learning environments that focus on the *"interaction between the affordances and constraints of the social setting, on the one hand, and the agency and biography of the individual participant, on the other"*. (Billett, 2004)

Hence the need arises for putting in place means to support workplace learning, as successful individual learning becomes an important parameter for the successful functioning of an organization. In recent years many training and e-learning methods and frameworks have been developed to help the employees learn about the business activities they are involved with. However state-of-art training and e-learning sessions are not as successful as aimed because:

- often the training session implies that workers need to devote extra-work time that is demanding and exhausting

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- learning curve for the training session itself is steep and apart from their business activities and hence workers are reluctant to take up the task
- setting up a learning environment similar to the working environment is very difficult for the company and usually costly and so workplace training becomes difficult for the company to setup

Companies look for alternative approaches to train the employees that can address the above issues. In our view the requirements for successful workplace learning should include:

- capability to simulate the actual working environment for the employees
- efficient and cost-effective set up of the training environment
- capability to track and customize learning tasks according to the profile of the employees

Given this context, *we propose BPMS as a tool that organizations can use for knowledge management and workplace learning*. This idea is at the core of the ongoing Learn PAd European Project, which is developing a new approach and a platform to learning at work (Learn PAd, 2015). The project aims at exploiting Business Process models based content for guided, personalized and collaborative learning sessions at work. The proposed approach leverages upon BPMS features such as collaborative execution between different users, web-service integration, process execution, etc. More precisely, the platform supports different types of approaches, including informative learning approach based on enriched Business Process models, and a procedural learning approach based on simulation and monitoring.

However BPM is not originally conceived for learning purposes. Therefore, in the Learn PAd project we are working at enriching the processes specification with meta-models related to learning content and training approaches, and at enabling the platform to support learning sessions.

As defined in (Janssen et al., 2008a), a sequence of activities and learning objectives customized to the needs and competencies of a learner is called a *learning path*. In this work we focus on the specification of a learning path over a BPMS-based Learning System – we call it BPMLS – and more specifically on how to enable such a system with means for monitoring and assessing the learning activities.

Model-based monitoring is traditionally used for on-line validation of systems behaviour; here we propose to employ monitoring of our learning path model during a learning session, with the purpose to inform both learners and trainers about the progress in the learning activities.

Since the mentioned Learn PAd project focuses on the Public Administration (PA) domain, to illustrate our approach, we use throughout the paper an example that represents a simplified process of a PA office, a Passport office.

The rest of the paper is structured as follows. After introducing some background information (Section 2) and the motivating example (Section 3), in Section 4 we present our meta-model of a learning path mapped to BPM models. Then in Section 5 we describe a model transformation techniques used for monitoring of learning activities. In Section 6 we describe a prototype and in Section 7 we walk-through our motivational example to show how the approach is used. Related work and Conclusions sections complete the paper.

2 BACKGROUND

This section will provide an overview of background concepts and technologies that are at basis of our work. In particular, our learning path specification and monitoring uses and combines concepts and definitions related to:

- Business Process Management discipline;
- Business Activity Monitoring systems;
- Workplace Learning approaches;
- Learning Path specification.

We already introduced informally **Business Process Management** (BPM) in the Introduction. More formally, we adopt here van der Aalst and coauthors operational definition of BPM (van der Aalst et al., 2003) as a discipline *supporting business processes using methods, techniques, and software to design, enact, control, and analyze operational processes involving humans, organizations, applications, documents and other sources of information*.

BPM spans over a complex life-cycle including stages of design, configuration, enactment and diagnosis (van der Aalst et al., 2003) . A **Business Process Management System** (BPMS) is a suite of software tools that leverage BPM concepts and covers some of the important components of the BPM life-cycle. Using a BPMS, process models are automated as workflow models that are then executed in a process engine. (Van Der Aalst and Van Hee, 2004)

Business Process Management Notation 2.0 (OMG: BPMN, 2011) (in the following referred to simply as BPMN) provides a standardized graphical notation for modeling executable business processes in a workflow. A workflow contains a sequence of business activities that may refer to the work of a person, group, or any business applications.

BPMS provide tools for: *i.* Process modeling, *ii.* Process Execution, and *iii.* Business Activity Monitoring (Van Der Aalst et al., 2003), among other things. In particular, **Business Activity Monitoring** (BAM) software can provide real-time access to critical business performance indicators for business activities executed by BPMS. BAM software applications use **Complex Event Processing** (CEP) techniques (Buchmann and Koldehofe, 2009), to process simple software-level events and derive higher level business events. CEP systems are advanced monitoring systems capable to combine data coming from multiple sources so to infer complex events that suggest more complicated circumstances. In particular, BAM collects raw data of interest during the runtime business process execution. These collected data are then analyzed by CEP and correlated to Key Performance Indicators (KPIs) and Goals defined for the process models. (Calabro et al., 2015; Koetter and Kochanowski, 2012) Key Performance Indicators consist of performance metrics that can be used to measure those aspects of organizational performance that are most crucial for success of the organization. (Parmenter, 2015)

By adopting a model-driven approach, BPMS can be adopted for design of platforms that can both inform and mimic business scenarios for adult learning. In fact, when the modeled business process reproduces operational process in the offices, such platforms can provide opportunities for the employees to acquire knowledge while actually doing the activity, or in simulation. This kind of learning is called as **workplace learning** (Billett, 2001). Workplace learning emphasizes participatory business practices for individual and collaborative knowledge-gain.

Within the learning context, **Learning path** is described as the chosen route, taken by a learner through a range of learning activities, which allows them to build knowledge progressively (Clement, 2000). It can be used to formally describe learning scenarios (Janssen et al., 2008a). A learning path includes a *learning flow* that defines an orchestration detail between a set of learning activities. (Mariño et al., 2007) Learning path specification should also define learning objectives or outcomes.

Several platform-independent Educational Modeling Languages have been proposed to describe learning paths. The IMS Global Consortium released the IMS-Learning Design specification that allows for defining the learning path as a Unit of Learning (UOL) (IMS Global, 2003). In (Janssen et al., 2008a), Janssen and coauthors have then provided a generic learning-path model that is mapped to IMS-LD.

The aim of this paper is to introduce a learning path specification that can be integrated to BPMS for workplace learning, and can be monitored using BAM systems. Our specification draws together the key concepts and definitions from Business Process Management discipline and from Workplace Learning approaches mentioned above. In future we also plan to evaluate the effectiveness of our Learning Path model through various empirical studies.

3 MOTIVATIONAL EXAMPLE

This paper is both inspired by and is part of the ongoing Learn PAd Project. We focus on procedural learning approach of learning by doing, whereby a civil servant can use the platform to learn about the tasks related to relevant business processes by performing a simulation of the activities. The scope of this paper includes the specification of learning path for workplace learning and methods to monitor and assess those learning paths during simulation. Though simulation is part of the Learn PAd platform, its implementation is out of scope of this paper. We refer to Learn PAd for details about the simulation component.

To illustrate our approach we introduce as an example the case of a Passport office that accepts and approves passport applications for citizens. Figure 1 shows a BP model that represents a simplified functioning of this office. As shown, accepting a passport application and issuing the passport is a collaborative activity involving two actors, namely a clerk and a passport granting officer. First, the clerk enter details of the passport applicant in a passport application management portal. Next step involves a complex process (abstracted in this example) where the passport granting officer will check the applicant's background record to verify if he/she is eligible for a passport. In the next step, the officer will be able to view the status of the application and based on the results from the background evaluation process can approve, withhold or reject the application. The verification may of course involve other public administrators and automated services, but here it will abstracted out as one single step. After verification, if the application needs further evaluation (which is dependent on the outcome of the previous step), the granting officer may have to withhold the application for further evaluation or can reject the application altogether. Else, he/she will grant the passport for the applicant and the process stops here.

In this paper we will be using the above example to demonstrate how learning paths are designed, exe-

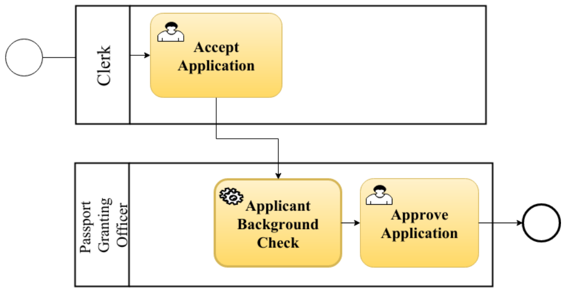

Figure 1: Example Process: Passport Office.

cuted and monitored.

Our goal is to provide learning path for the above process that can be executed and monitored in the framework that we will define in the later sections. Different learning paths can be defined to reflect the proficiency expected from the employees of the office. They may also be based on organizational policy. For example, since passport issuing is a security-sensitive process, the learning path might want to ensure that all procedures are followed without any errors during the learning process. The office policy might also require that the passport be issued within a predefined time limit. We will show in the following how such conditions can be modeled and enforced in learning design using our learning path specification and monitoring approach.

4 LEARNING PATH META-MODEL

A learning path specification (IMS Global, 2003; Janssen et al., 2008a) must identify both the sequence of activities and the related learning objectives reflecting the specific context and tailored to the learner's competences.

When it comes to defining learning paths for knowledge based on business process models, the specification of the learning flow and the learning objectives must then comply to the following key requirements:

- Learning flows for business process models have to be represented by their workflow structure. In other terms, what an employee learns in relation to a business process should conform to the sequencing of rules established by the business process model.
- Learning objectives for business process models should be correlated to Key Performance Indicators (KPIs) of business activities that form the learning path.

Our learning path specification is conceived to address the above requirements. In fact, the specification we introduce here *maps KPIs of business processes to learning objectives of the learning path.* Figure 2 represents the meta-model of our learning path specification. This specification allows us to define a learning path on top of a BPMN specification. Precisely, we extend the BPMN meta-model with the introduction of classes and attributes related to a learning path. In the figure, classes with grey background are related to the BPMN model. Classes with yellow background (those that we introduce) are related to the learning path specification.

LearningPath class is extended from **Process** class, that is used to formally represent the business process model within BPMN. (**Process** class is explained in detail in the BPMN specification to which we refer for further details). **Process** instances can be extended with **LearningPath** only when the attribute *isExecutable* is set to true. This is to ensure that learning paths are defined only for deployable BPMN process models, given that we intended to use the business process model for simulation.

An instance of **Process** (with *isExecutable* set to true) can be used to initialize one or more instances of **LearningPath**. During the initialization, values of **Process** attributes are copied to their corresponding attributes in the **LearningPath** instance, and attribute *process-ref* of **LearningPath** is used to refer to the **Process** instance. A instance of **LearningPath** can be executed in the BPMLS through model transformation (which we will explain in Section 5) to **Process**.

Many **LearningPath**s can be created from one instance of **Process**, and each instance of **LearningPath** represents one learning session. The *Id* attribute of class **LearningPath** is used to uniquely identify a learning instance. The *prerequisites* attribute is an array of type **LearningPath** and points to a list of **LearningPath** instances that needs to be executed before the current **LearningPath** can be in turn executed. Attribute *objectives* is used to set the learning objectives for the learning path and is an array of type **KPI**. We will describe the class **KPI** below.

Process and **LearningPath** may contain one or more instances of **Task**. A **Task** class represents an atomic activity within **Process** flow. For every **Task**, a **LearningTask** instance maybe created. **LearningTask** inherits all attributes from its parent **Task** instance, and has an attribute *task-ref* which is a pointer to its parent *Task*. *Id* is used to identify the learning task. *resource* is used to restrict the learning activities to a group of users and is derived from *ResourceRole* class of BPMN specification.

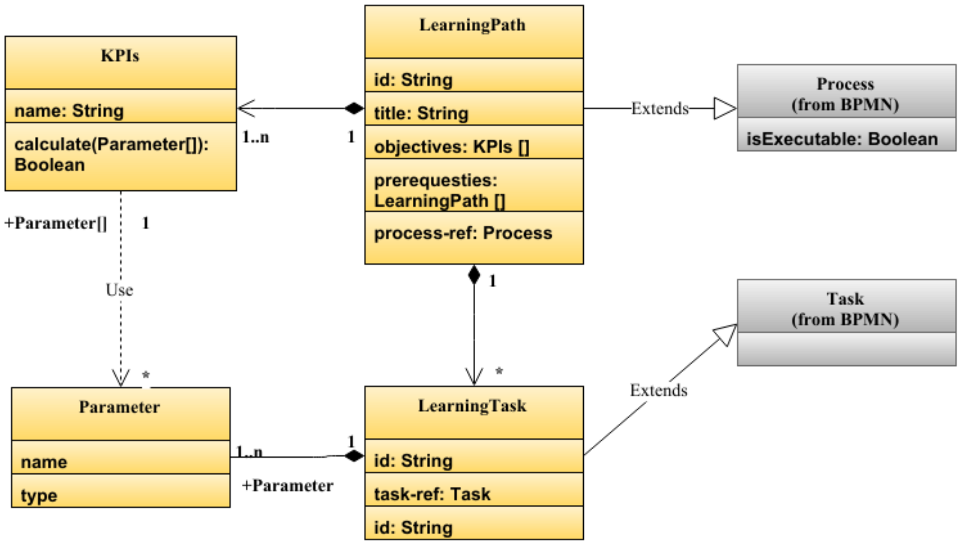

Figure 2: Learning path specification for business process model.

LearningTask contains one or more instances of **Parameter** class. **Parameter** class captures values that are used for monitoring purposes. **Parameter** class contains attributes *name* and *value*. *name* is used to uniquely identify the instance of **Parameter** and *value* is set during the learning session based on the output from **LearningTask**.

One or more instances of **Parameter** can be used within **KPI** *calculate()* function. The *calculate()* function returns a boolean value and is used to check if a given Key Performance Indicator for the business scenario is fulfilled. As mentioned above, an array of **KPI** can be used within the attribute *objectives* of **LearningPath** to define its learning goals.

In this section we have provided a learning path specification for business process models. In the next section we will provide a model transformation technique to derive business process models and CEP queries that can then be executed within BPMS and BAM respectively.

5 MONITORING OF LEARNING PATH MODELS

The Learning Path meta-model defined in Section 4 can be used to define many learning related properties on top of business process models. Several BPMS exist that can understand BPMN models, and hence it is more convenient to reuse existing BPMN compliant execution platforms to design BPMLS learning platforms. We believe that a BPMS can be extended into a BPMLS platform if the following three functionalities can be included:

- **A model to Specify Learning Path on Top of Business Process Models:** This is what we provide in Section 4.
- **A platform to Design Learning Models:** It can be a tool developed on top of BPMS modeling tools. This work is currently in progress within the Learn PAd Project, and we are not covering this in this paper.
- **Methods to Monitor and Assess the Learning Progress of a User:** In this section we will focus on this latter functionality.

BPM methodology already includes monitoring capabilities within its life-cycle. A BAM software can provide real-time informations about business process executed using BPMS. An effective workplace learning platform should also be able to monitor and assess a learner's progress. A BPMLS can extend the functionalities of BAM for monitoring and assessment of the learner.

Using the learning path specification previously introduced, we developed a model transformation technique to derive business process models and CEP queries that can then be executed within BPMS and BAM respectively.

An overview of a unidirectional model transformation is represented in Figure 3. A standard BPMS engine can be used to deploy process definition defined using XML representation of BPMN. On the other hand, CEP queries can be defined within a BAM software either as SQL-like queries or a set of rules depending on CEP engine specification. Since monitoring is out of scope of BPMN specification, the BPMN meta-model provides a generic Monitoring meta-model that allows defining attributes related to monitoring. It leverages the BPMN extensibility mechanism. The actual definition of monitoring attributes is not provided in BPMN specification and BPMN 2.0 implementations define their own set of attributes and their intended semantics. (OMG: BPMN, 2011)

The goal of our transformation technique is to accept both the learning path model as well as its referenced business process model and provide two forms of outputs that can be executed within BPMS and BAM respectively. The transformation involves two steps:

1. Creation of BP models with monitoring probes: In this step, for each of the **LearningTask** a transformation is applied to its corresponding **Task** of the business process model. The relationship between **LearningTask** and **Task** is identified using the attribute *task-ref* of **LearningTask**. The transformation involves addition of monitoring probes that sends values defined by **Parameter** of **LearningTask**.
2. Creation of CEP Queries: Since a learning path specification is an atomic learning process and corresponds to one process instance within BPMS (as described in Section 4), a single complex-event unit is defined for one **LearningPath**. BPMS engine takes values of **Parameter** from its system and the value is sent to a CEP engine through the monitoring probes. The CEP engine executes the functions defined in **KPI** class, which are related to *learningobjective* of a **LearningTask**

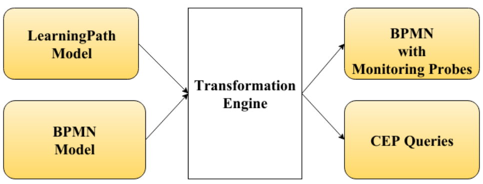

Figure 3: Overview of Model Transformation.

6 PROTOTYPE

A prototype was developed to evaluate the learning path model transformation and assessment techniques. It is conceived such that an employee who needs to learn about a business process can log in to the system and will find an environment mimicking the real business process for learning purposes.

Figure 4 represents the overall framework of our platform. The framework consists of four main components:

i. Transformation Engine to transform learning path model into BPMN model and CEP queries respectively
ii. Process Execution Engine to executed the transformed BPMN model
iii. Monitoring Framework to monitor and assess a learning path
iv. A User Interface for displaying learning progress to the users.

The transformation engine was developed based on the description provided in Section 5. Currently the transformation is performed in a semi-automated way, where the BPMN models are generated automatically and later manually updated with the required monitoring probes. CEP queries are also generated manually (explained in the later part of this section). We are in the process of automating the transformation technique.

For the Process Execution Engine we use Apache Activiti, an open-source Java-Based BPM Platform. (Rademakers, 2012)

For monitoring we use Drools Fusion (Drools Fusion 6.0.3, 2015) based CEP engine. Drools fusion provides mechanism to declare rules that can be used to read a stream of events and infer a complex event based on the conditions defined in the rule. Apache Explorer is used as the user interface component and has been extended to display the learning progress to the users.

Apache Activiti provides with mechanism to execute external Java Code, called execution listeners, when certain events occur during process execution. The events can be defined on the level of process, activity or transition levels. The execution listeners are useful to capture process-level variables that are generated during execution and send them (say as web service calls or REST calls) to a monitoring framework.

During the model transformation from learning path model to business process model, execution listeners are created for every *Task* (referred as Activity in Apache Activiti Parlance) that has **LearningTasks** related to it. The execution listener contains methods to read *Parameters* values and send them to the monitoring framework.

A overview of the relation between objects of different components such as learning path model, BPMN model, events and Drools Fusion CEP rules is provided in Figure 5. A **LearningPath** object has **LearningTasks** that contains **Parameters**. After model transformation, every **LearningPath** has a

Process. **Activity** corresponding to **LearningTasks** has execution listeners that collect **Parameters** values. A **Process** triggers 'start' and 'end' events whereas **Activity** triggers only 'end' event. The execution listeners send the values of **Parameters** as and when the events are triggers. CEP rules receive and monitor the events. CEP rules element has functions to calculate KPIs based on the received events, whereby the function to calculate the KPI is derived from *KPI calculate* function from the learning model.

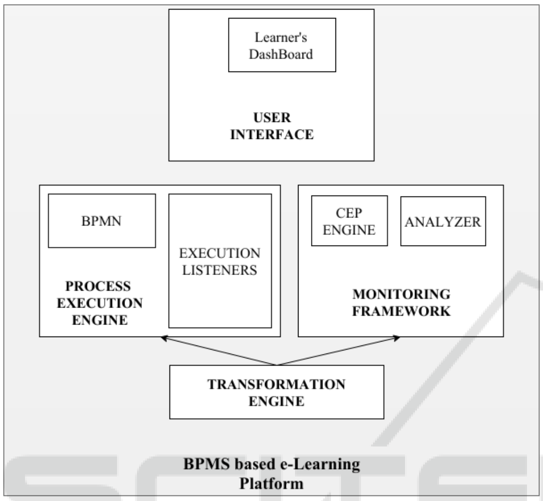

Figure 4: Framework for Learning Path Execution and Monitoring.

7 APPLICATION EXAMPLE

With reference to the motivational example introduced in Section 3, an instance of Learning Path specification is provided in Figure 6. It contains three *LearningTasks* attached to *LearningPath* that correspond to each of the tasks presented in the example, namely: 'Accept Application', 'Check Application', and 'Approve Application'. Instances 'Accept Application' and 'Check Applications' have one *Parameters* each, while 'Approve Application' has two *Parameters*. There is one *KPI* that is associated with *Objectives* of **LearningPath**, and the calculate function contains the following function:

$$Beginner\_Time\_SLA = (Approve\_Application.timestamp - Accept\_Application.timestamp) < \$expectedSLA \ \&\& \ valid\_entry = true$$

&expectedSLA is a variable that can be defined by an administrator to denote the completion time of the process. It can be noted that the **KPI** instance access the *values* of the *Parameter* class.

The KPI *Beginner_Time_SLA* is defined as difference between the time when application was accepted and approved and is converted to an integer indicating the difference. It will return true if *Beginner_Time_SLA* is less than *expectedSLA*, or false otherwise. This goal will be used to check if during the simulation in learning the process is completed within expected deadline and defines the learning objective of the *Beginner* **LearningPath**.

During model transformation, the Tasks in Business Process models is added with appropriate execution listeners that will be used as monitoring probes to send the *Parameter* values to the CEP engine. For example, Listing 1 below provides the XML definition for the activity 'Accept Application' with execution listeners.

Listing 1: BPMN specification with execution listeners.

```
<userTask id="acceptapplication" name="Accept
        Application" activiti:assignee="clerk">
    <extensionElements>
        <activiti:formProperty id="name" name="Name"
            type="string"></activiti:formProperty>
        <activiti:formProperty id="id" name="
            Identification" type="string"></
            activiti:formProperty>
        <activiti:executionListener class="org.
            activiti.monitor.
            AcceptApplicationEventLst" event="end"
            />
    </extensionElements>
</userTask>
```

During execution, when the 'Accept Application' task is ended, the process execution will call the listener **AcceptApplicationEventLst**.[1]

Similarly, CEP rules are created for each of the learning path model, and are deployed within the Drools Fusion CEP engine. Listing 2 provides a skeleton rule file for the beginner learning path. At time of writing, rules are created manually and automation is ongoing.

A sample application was developed based on the prototype defined above. As mentioned above, Apache Activiti Explorer was used to design, and execute the process models. Learning path model and its corresponding business process models, CEP rules were created separately. The explorer interface was modified to detect and display the learning progress to the users. Figure 7 provides a screenshot in which the 'Approve Application' task is executed. Figure 8

[1]In technical terms, **AcceptApplicationEventLst** instantiates a Plain Old Java Object (POJO) **AcceptApplicationEvent** and sets a *timestamp* property to indicate the time when the 'Accept Application' event is finished. Likewise the model transformation creates execution listeners for each of the **LearningTasks** provided in the learning path model.

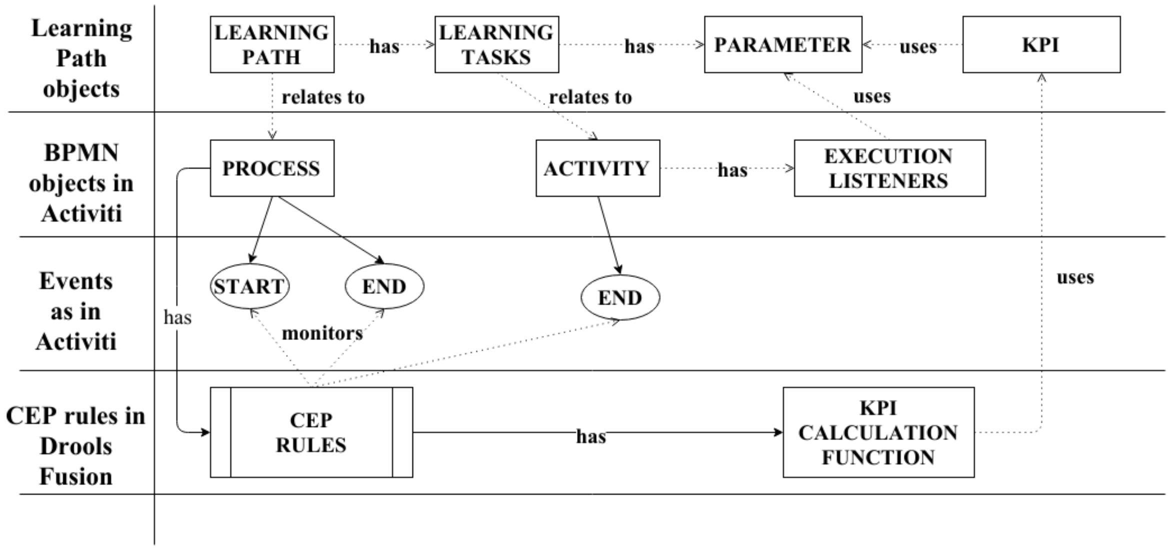

Figure 5: Overview of relation between objects of different components.

provides a screenshot of a simplified webpage where the progress of the learner is registered. (note that the screen contains references to another learning path called ‘Advanced’. This is to showcase that many learning path models can be created.)

Listing 2: CEP rule for a learning path model.

```
rule "Beginner- Learning Path Monitoring"

when
 #conditions
 #calculate KPI functions as defined in the learning
        path model

then
 #update the learning path as completed
```

8 RELATED WORK

Different approaches have been considered for assistance of lifelong learning for individuals such as the European Union project TENCompetence (Koper and Specht, 2006) which developed a framework within which daily competence development activities can be carried out. Within the broad category of workplace learning, some research community have tried to use BPM concepts for the management of collaborative learning processes. Marino and coauthors (Mariño et al., 2007) proposed a method to transform learning design models defined using IMS-LD specification to business process execution model called XML Process Definition Language. The goal was to use IMS-LD for defining a learning design and use business process engine as a delivery platform for the learning designs. In (Karampiperis and Sampson, 2007), Karampiperis and coauthors examine using of BPMN as a common representation notation for learning flows modeled using Business Process Execution Language (BPEL) and present an algorithm for transforming BPEL Workflows to IMS-LD learning flows.

Vantroys and Peter (Vantroys and Peter, 2003) presented Cooperative Open Workflow (COW), a flexible workflow engine that can be used to transform IMS-LD into XPDL designs to enact the learning models in the platform. Another e-learning platform called Flex-el (Lin et al., 2002) has also been built on top of workflow technology. It provides a unique environment for teachers to design and develop process-centric courses and to monitor student progress.

Above discussed methodologies and platforms focus on using BPM techniques and technologies for designing learning specifications for academic scenarios and do not focus on workplace learning.

Regarding learning path specification, Janssen and coauthors proposed learning path information model that can represent a formal learning path model (Janssen et al., 2008b). However, the specification is generic and does not address the requirements of workplace learning based on BPM.

As far as we know none of the existing works focuses on using BAM for workplace learning monitoring. In their work, Adesina and coauthors focus on visually tracking the learning progresses of a cohort of students in a Virtual Learning Process Environment (VLPE) based on the Business Process Management (BPM) conceptual framework (Adesina and Molloy, 2012). Their work focuses on learning specifications for academic scenarios and does not focus on

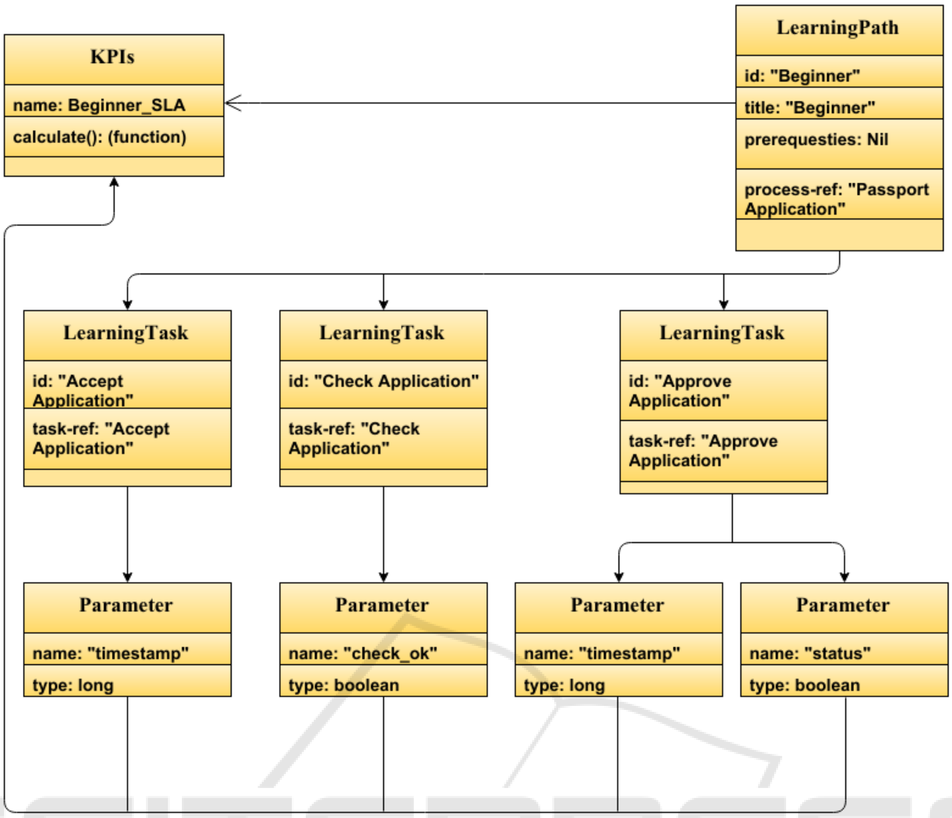

Figure 6: An instance of Learning Path model.

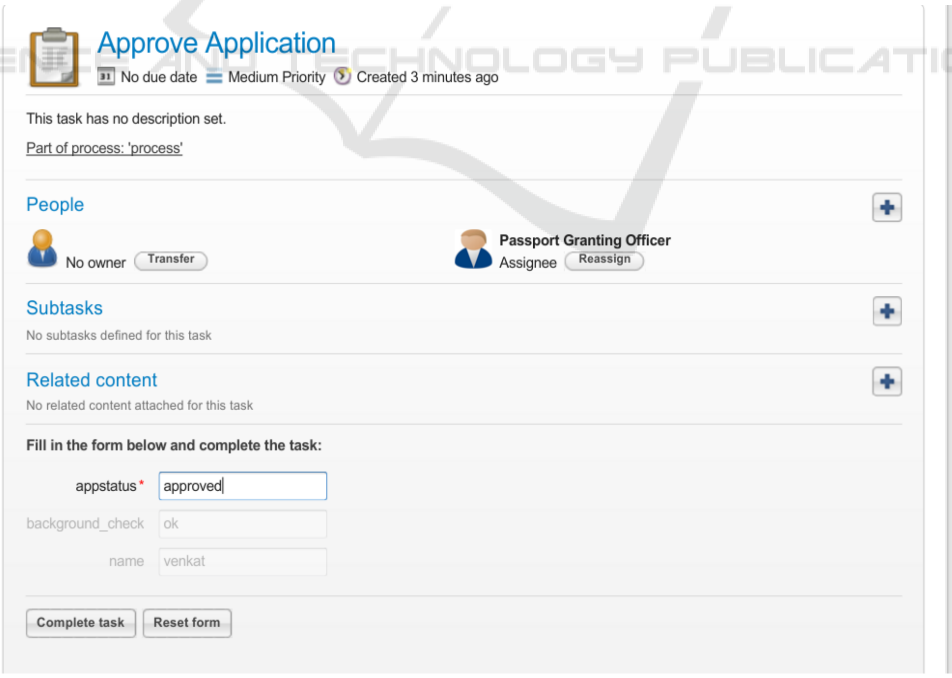

Figure 7: Execution of Approve Application task.

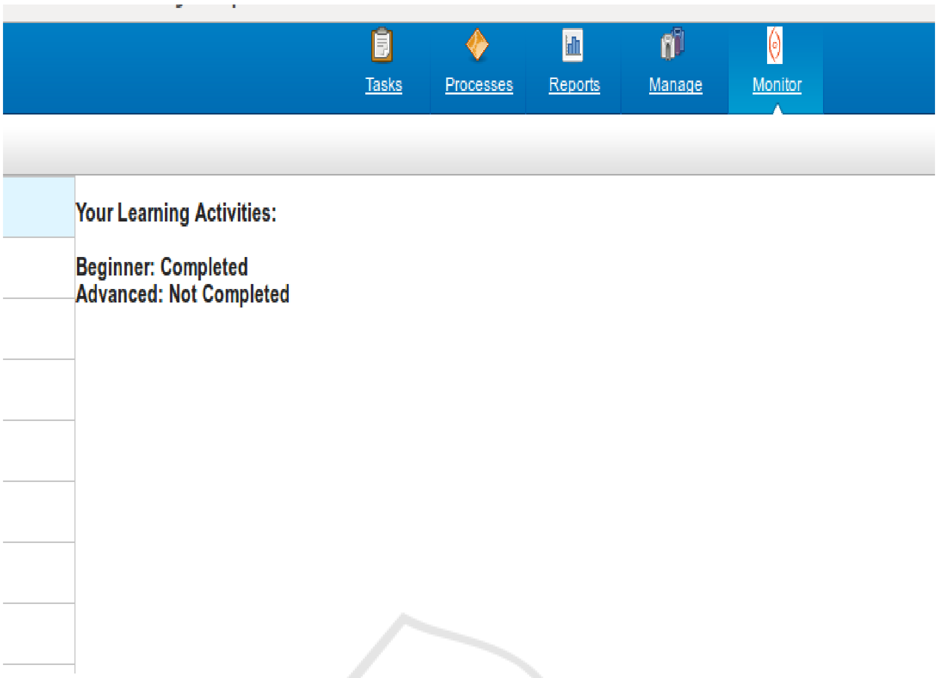

Figure 8: A Simple Screen to display learning progress.

workplace learning. Also their tracking of the learning progress does not leverage BAM systems.

Our work defines a precise specification that can be used for defining learning path for business process models, as well as transformation techniques for using standard business activity monitoring techniques to monitor learning progress of an employee.

9 CONCLUSION AND FUTURE WORK

Our research aims at exploiting the potential of BPM to support effective and realistic workplace learning activities. BPMS solutions used at work are very powerful and widely used, but they are not conceived for learning purposes. To the best of our knowledge there is no existing proposal to adapt BPMS for learning needs by extending the notation to define a learning path.

This work in particular aims at filling the gap between BPM used for work, and workplace learning needs by extending BP models with features to specify learning flow and learning objectives. This stays within the context of the European Learn PAd project, that aims at exploiting enriched BPMN models for deriving both recommender systems and simulation sessions used expressly for learning the modeled sequence of tasks by workers.

We introduced a preliminary specification of learning path that extends the standard BPMN specification by including learning relevant concepts. We then proceeded to provide a model transformation technique from learning path specification to queries that can be directly sent to a CEP to monitor and assess learner's progress.

We are currently refining platform implementation, and testing it on several scenarios defined within the Learn PAd project. In particular, future work will focus on methods to automate the generation of CEP queries for learning path monitoring. In future we are also looking at integrating the simulation environment of Learn PAd platform thereby making it possible to define learning path models for individual users such that the collaborative activity of other users can be simulated using the system.

ACKNOWLEDGEMENTS

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