Towards Model-Based User Interface Development of e-Learning Management Systems

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Abstract. The article discusses the need for a methodology to support the development of learning management systems. The Web browser has been the traditional way to access such system but emerging technologies presents new challenges. The problem is not just on the technology to support the learning process but also the lack of design knowledge to assist teachers to create content taking into account both the heterogeneity of the learning content and students. These issues are discussed and a proposal is presented to address them.

Keywords: Learning process, workflow systems, multicultural learning objects, e-Learning, model-based development, user interface.

1 Introduction

The design of a teaching-learning process is a task that all professional education must be taken when planning to develop an activity teacher training: course, seminar, etc.

The learning process links users to domain-specific information sources in collaboration spaces designed for knowledge transfer and knowledge generation. Becoming efficient and stimulating for better and effective learning process using available technology requires a strategy to follow. The strategy must consider at least: design of learning content, design of different ways to present content (textual, graphical or mixed) considering different devices (PDA, mobile phones, laptop), and defining collaboration during learning process.

In the design of a learning process, a problem is to correctly identify the context (student, environment, technology available). As depending on this, the teaching strategy, resources, content, and evaluation criteria, are selected. Once content is

created, it must be advertise to those stakeholders involved, such as: teachers, students, managers, etc. [1].

Learning processes are viewed as a workflow (depiction of tasks during which documents or information is passed for one participant to another according to a set of rules) that is recursively decomposed into tasks, that could be associated to a learning object (LO).

The term e-Learning has been introduced to denote learning with the aid of information and communication technology tools [2]. e-Learning still suffers from several usage difficulties, both objective and subjective, such as: the long tradition of classroom education, possible negative experiences with first generation products, a background of badly organized self-teaching attempts, the lack of the typical interaction and emotional relationships that can be obtained with a frontal lesson. The organized problem represents one of the main reasons of on-line courses drop-out.

Recently there are a growing number of researches [3, 4] that put emotions at the centre in the process of teaching-learning. These studies reveal the importance of the learner's emotional states and, in particular, the relationship between emotions and effective learning [4]. However, the influence of emotions in learning processes is not considered in this work.

The obejctive of this work is to define the requierements and to design a possible solution to the aformentioned issues. The organization of this paper is as follows: Section 2 presents a brief background, Section 3 presents our methodology to support learning processes and multicultural learning objects support. Finally, the paper is wrapped up by summarizing our work, deriving conclusions and addressing future trends.

2 Related Work

There is a plethora of computer-assisted e-Learning Management Systems with common elements, such as: tools for creating course material, assessment as well as collaborative tools (forums, emails and chats). These tools achieve the main goal of a system which is to deliver learning content during and after the lecture, i.e. synchronous and asynchronous learning modes.

User Interface Development Methods for e-Learning Environments are scarce, we are not aware of others than [6-9]. In general, a method for designing and developing a learning management system uses a formal specification technique to model the evolution of learning process. In the literature, some methods have been reported and are summarized in Table 1.

The characteristics of the comparison are those that we identified as challanges for a novel e-Learning system, including the design knowledge that is found on formal methods, framework, adaptation or personalization to the user, support to render the User Interface on multiple devices, means to trace learning objectives.

3 Challenges to Create a Methodology to Support Learning Process Definition

Our target is to ensure the transfer of a collaborative learning environment where the user interface (UI) is multi-platform (PC, laptop, and mobile devices) and adaptable to multiple contexts of use (user, device, environment). And in such context facilitate the user (teacher and students primary) the exchange of information more naturally through a UI conceived systematically using this approach.

Table 1. Comparison of collaborative learning environment design methods (Source [6]).

Criteria/Work	(Jonassen et al.) [7]	(McDonald et al.) [8]	(Germán et al.) [9]	(González et al.) [6]
Formal specification technique	*Activity theory*	*Conceptual framework*	*State machine*	*Workflow*
Framework	*NonA*	*C-Flow*	*Cated*	*Ecool*
Personalization	+	+	-	++
Multiple User interface.	--	+	--	++
Traceability of collaborative learning	–	--	+	++

(++ fully supported, + supported, - partially supported, -- not supported)

We argue that creating learning content is an activity that would benefit from the application of a development methodology [10] which is typically composed of:

- A set of models defined according to an ontology. The term "ontology" generates some controversy. It has its history in philosophy, where it refers to the subject of existence. It is also often confused with epistemology, which is about knowledge and knowing. In the context of this research is assumed a set of descriptions of the concepts and relationships within a field of knowledge (learning process).
- A language that expresses these models. In order to specify different aspects and related models, a specification language is needed for allowing designers and developers to exchange, communicate, and share fragments of specifications and that enables the tools to operate on these specifications. These models are uniformly and univocally expressed according to a single Specification Language. A User Interface Description Language (UIDL) is needed and its selection could be based on [11]. A genuine UIDL must be strongly defined based on a trilogy (semantics, syntax, stylistics) [6]. Offering a XML language does not necessarily assures to rely in this trilogy [10].
- Principle-based method manipulating these models based on guidelines. The goal is not to come up with yet another Software Development Method but to reuse existing work and structure it accordingly. The result is a method that structures the development life cycle of learning content in a principle-based way. The method

should promote an exploratory approach having as goal to show a variety of possibilities to encourage design.

— Tools: A suite of software engineering tools that supports the designer and the developer during the development life cycle according to the method. The set of software tools required to support the development of learning content includes:

  - Model editors to assist a designer in constructing the models. These tools consist in syntax editors, form based tools, or visual builders. Some model editors maintain a textual specification consistent with a graphical representation.
  - Design critics provide a designer with quality assessment facilities. Models capturing explicit properties of the artefact are an ideal representation to perform evaluation.
  - Implementation tools translate a specification into a representation that can be used by a compiler, an interpreter or an interface builder.
  - Transformation tools provide support to the designer to edit, store, and execute model transformation rules.

Building the application using the right tools is a trade-off between six main criteria [12]:

1. Part of the application built using the tool. Some tools only support building the presentation part of the application; others also help with low-level interaction, and some support general programming mechanism usable in other parts of the application as well.
2. Learning time. The learning time of the tools varies.
3. Building time. The time required to build a UI using the tool varies.
4. Methodology imposed or advised. Some tools strongly impose a methodology for building the application, such as building the visual part first and connecting it into the reminder of the application afterwards, whereas other tools are more flexible.
5. Communication with other subsystems. Applications frequently use databases, files located on the Web, or other resources that, when supported by the building tool, simplify the development.
6. Extensibility and modularity. Applications evolve, and the new applications may want to reuse parts of existing applications. Supporting the evolution and the reuse of software remains a challenge. Level-4 tools and application frameworks, including Model-Driven Architecture (MDA), inherently promote good software organization, but the others usually lead to poor extensibility and modularity.

The proposed system (depicted in Fig. 1) is composed of several subsystems interconnected together to form an entire collaborative learning environment with social networks. These subsystems will allow on one hand focusing the content and online courses; and on the other hand, students may also use these environments to collaborate with other students in online communities and have advice from teachers college. The following subsections describe more details about the different layers of the methodology.

3.1 Supporting Multicultural Learning Objects

A learning object (LO) is defined as a self-standing, reusable, discrete piece of content broken down into smaller chunks that can be reused in any environment in order to meet an instructional objective. The way LOs are conveyed includes: Web pages, PDF documents, video and/or audio content, animations, and virtual reality to mention a few. LOs have been developed to support virtual learning using technology and pedagogical support. These products can be used under any condition or circumstance where the training or the distribution of the knowledge is required: classroom lessons, staff training in the industry, self-learning process, among others. Adding the multicultural characteristic going beyond regions is a real challenge. For this purpose a LO model is needed. The structure of a LO is specified with: a name, a context, authors name, date, brief description, participants involved, pre and post conditions, and normal and/or alternative learning process flows. The LO model could be a simplified version of SCORM standard. A LO can be part or be composed of other LOs. Also, it can be associated to exercises and/or assessments. The LO is part of a task and will be used in a task, this information is relevant when further we explain how a LO is mapped to a UI from a task model.

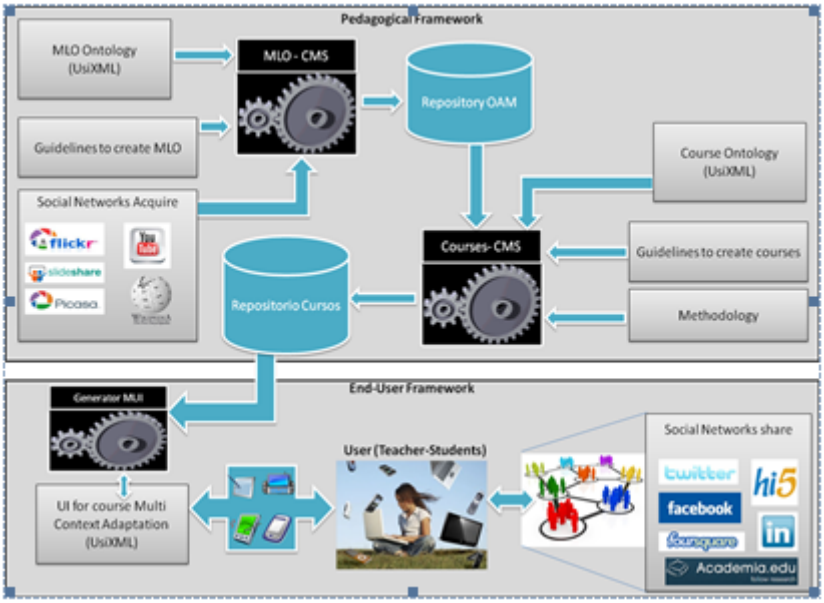

Fig. 1. Methodology to support the learning process definition.

To create the knowledge base related to the Multicultural Learning Objects (MLO) in a formal expression is necessary to make trades to support operations such as extraction of knowledge or recommendations for use, among others. After this, it is

necessary to establish a method that indicates the steps to be followed for the creation of MLO.

Including guidelines to support the method is desirable for the systematic creation of MLO. These guidelines will be based on existing knowledge related to the creation of MLO. Determine the level of automation of the guidelines and application will use the software tool developed for the creation of MLO. This activity focuses on the definition and establishment of methodological guidelines for the creation of MLO. Then, each guideline is classified according to the automation criteria (can be automated or not, or can be partially automated). As the ultimate goal is to automate this method in a software tool, guidelines that cannot be automated at all are useless.

A software tool is desirable for the faster and reusable creation of MLO. It aims to create a Content Management Systems (CMS) for creating MLO. A content manager is a software tool for creating online content simply and massive. This tool will support the proposed method and its use to allow many users to create MLO. One of the requirements for a CMS for MLO creation is the integration of multimedia, such as: audio, video, power point presentation, documents. With the introduction of cloud computing and the use of social networks, such as: slideshare (slides), Wikipedia (free encyclopedia), YouTube (videos), Picasa (photos), among other, to share content, we can avoid storing multimedia in the LO´s repositories. The integration of access to social networks is essential to give versatility to the CMS. Each time you create a MLO, the CMS guides the user with an assistant, and the wizard must go step by step guiding the creation of MLO, relying of the automated guidelines. Special care needs the UI for this MLO-CMS preserving ergonomics, guidelines, heuristics and usability principle. The editor will safeguard, update, edit, access, search, and display settings under different criteria and the MLO repository.

3.2 Supporting Learning Process Definition

A number of online services assist the task of structuring academic courses, relevant and adaptable [13] to the context of students, including learning styles recognition [14]. However, integrating those efforts and to connect them to MLO is more than just a technological problem. A Learning Management Systems (LMS) must consider not just the content adaptation and student learning styles identification, but also to provide teachers means to create content accurately. Most related work assumes that learning content is already there but do not assist the teacher who normally is not an education expert.

For this reason, a mechanism to assist teachers for creating a course is our first requirement for a learning process definition software tool. The software tool should have a CMS for courses. This activity focuses on the development of software tool that serves as content manager for the creation of courses, a module in a learning management systems platform. This tool benefits from the MLO module as it uses material available in the MLO format. The main features for such system are: a) integrating pedagogical recommendations to create a system of guidelines for the creation of courses; b) identify multicultural issues in education; c) identify different

forms of education (classroom, mixed, distance); d) integrate this information in the specification of a learning process; e) integrating intelligent management of information in the learning process; f) integrate MLO information.

As automatic integration of guidelines to use the tool for defining courses content, assistive interaction is needed (wizard, intelligent agent) to guide teachers in this activity. Education experts are needed to define methodological guidelines for the creation of courses. These guidelines should include multicultural aspects in education, different education and different learning paths.

The manager must have a content editor for courses. A learning process can be described as a workflow model [15] that is composed of tasks, resources and places where education takes place. The workflow model is recursively decomposed into learning processes which are in turn decomposed into tasks. Now, as there are many different learning types and approaches to learn, this is believed to occur as a progressive series of tasks, i.e. a workflow. So, a workflow model can be used to plan and to design the process of all aspects of learning. There is a teaching process for the trainers, a learning process for the learners, an organizational workflow for all participants, and a management workflow. All these components interact with each other to form an overall learning workflow. A graphical representation (Fig. 2) of a learning process uses a Petri Net [16] for the specification of processes, big rectangles denoting the rooms where the teaching activity takes place, and roles (students and professors).

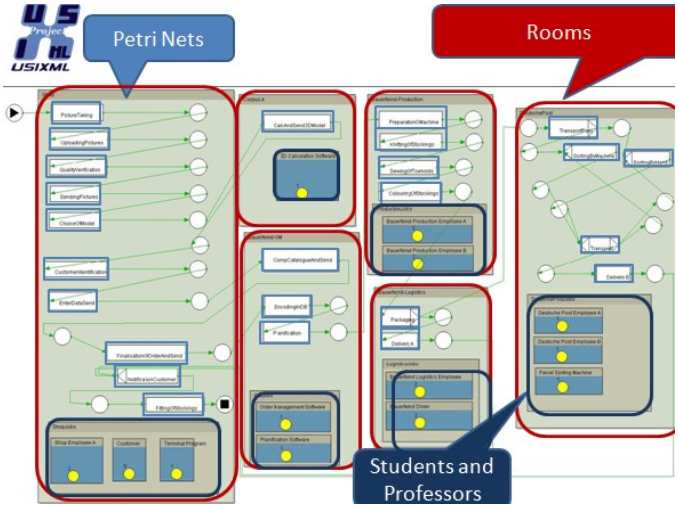

Fig. 2. Learning process editor.

It is vital that the editor considers computer human interface usability. Ergonomic guidelines should be taken into account in the development of this editor; its good design will allow easy use. The editor will safeguard, update, edit, access, search, and display settings under different criteria and the courses. The IU "friendly" is vital and as such must be designed carefully since it depends on the successful use of the

manager. As each rectangle in a Petri net denotes a high level activity or task, more details are needed to describe how those activities are required, in which order they must be executed, thus a task model. There are several notations for task modeling but CTT [17] is a good option because isan expressive and flexible notation able to represent concurrent and interactive activities, also with the possibility to support cooperations among multiple users and possible interruptions. A second reason, task modeling has been used to generate multi-context UI, as it is explained in the next subsection.

This method should also consider elements such as academic monitoring, assessments (for instance using the method of assessment adaptation proposed in [18]), practices and exercises, and other traditional elements considered in a course. The systematic creation of courses based on a method will allow having more quality content. Furthermore, the method will provide the basis to create a tool to automate and thus to create content as a whole.

One important aspect is to consider the other side of the problem, i.e., to consider the student perspective. Showing progression in learning paths progress has been reported [6] as a way to improve users' awareness of its progress; however they fail to motivate him into achieving its goal. How to keep students attach to their learning activities? One idea is to use the famous metaphor created by the site LinkedIn of small progress with great results (your CV online). Seducing the student with the UI is more than rather than the technology itself. Seductive interaction [19] is a way to keep users attached to the system and performing their goals (Fig. 3).

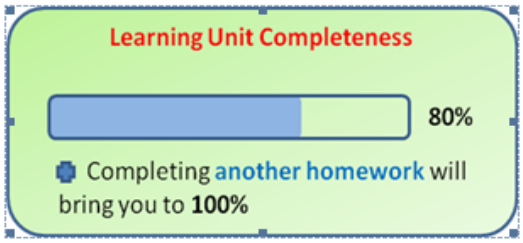

Fig. 3. Learning Progress metaphor inspired from LinkedIn (www.linkedin.com).

3.3 Multi-Context User Interfaces Rendering

Considering that learning process is a description of the foreseen interaction among the following actors: instructors, learners and the system, it captures the context in which the learning process occurs, the process and associated data, and the order of tasks execution; our proposition starts by defining it in a formal definition using a learning process, i.e., a set of tasks. In this step we can indicate the resources involved, the rooms where they work, how and in which order tasks will be executed (using task model [17]); after, MLOs which are associated and stored in a repository, this could be done using the recommended methodology described above or by relying on existing work, for instance MACOBA [20].

Even that the platform of choice for most of the learning environments is the Web browser [21]. A learning portal should seek not only to reuse the tools available on the Web, also will seek to adapt the system to follow the principles of multi-context adaptation of user interfaces (users, environment and platform). Model-Based Development of User Interfaces has been widely reported in the literature [17], [22], [10], to address this problem. The Cameleon Reference Framework [22], the de facto standard, in a simplified description, structures four development steps: 1) Task & Concepts (T&C): describe the various user's tasks to be carried out and the domain-oriented concepts as they are required by these tasks to be performed. 2) Abstract UI (AUI): defines abstract containers and individual components, two forms of Abstract Interaction Objects by grouping subtasks according to various criteria, a navigation scheme between the containers and selects abstract individual component for each concept so that they are independent of any modality.

An AUI is considered as an abstraction of a Concrete User Interface with respect to interaction modality. At this level, the UI mainly consists of input/output definitions, along with actions that need to be performed on this information. 3) Concrete UI (CUI): concretizes an abstract UI for a given context of use into Concrete Interaction Objects (CIOs) so as to define widgets layout and interface navigation. It abstracts a final UI into a UI definition that is independent of any computing platform. Although a CUI makes explicit the Look & Feel of a final UI, it is still a mock-up that runs only within a particular environment. A CUI can also be considered as a reification of an AUI at the upper level and an abstraction of the final UI with respect to the platform. 4) Final UI (FUI): is the operational UI, i.e. any UI running on a particular computing platform either by interpretation or by execution.

The user interface design processes starts with a task model that is processed through an incremental approach to the final UI (Fig. 4 shows the four levels that are involved in the design of a UI using the Cameleon Framework).

From a task model specification it is possible to derive as many UIs as devices have been specified in the framework, for instance UsiXML is capable of rendering learning content on Mobile devices and a Smartphone, as it covers the multi device and multiplatform support. For the complete definition of the method, the reader should refer to [10].

Models are everywhere and are needed to support the Model-Based Development of User Interfaces for learning management system. Even more there is another advantage adopting this approach that is the automatic evaluation and assistance, a key added value if we want to keep the users satisfied.

As reported in [23] the traditional shortcomings of automatic evaluation of UI are addressed by relaying on working with models. The common major shortcoming of any evaluation tool is that the evaluation logic is hard coded in the evaluation engine [23]; for example, two leaders of the web evaluation market, Bobby and A-Prompt only provide the choice of the guidelines set to evaluate: W3C or Section 508, which makes them very inflexible for any modification of the evaluation logic or any introduction of new guidelines. The global process for automatic evaluation of the Model-based approach is depicted in Fig. 5. The "Knowledge Base" contains a formalization of rules for good ergonomics and accessibility. This knowledge base is

a collection from ergonomic guidelines, for instance, structures or various recommendations that are encoded in a formal format, using the UsiXML language.

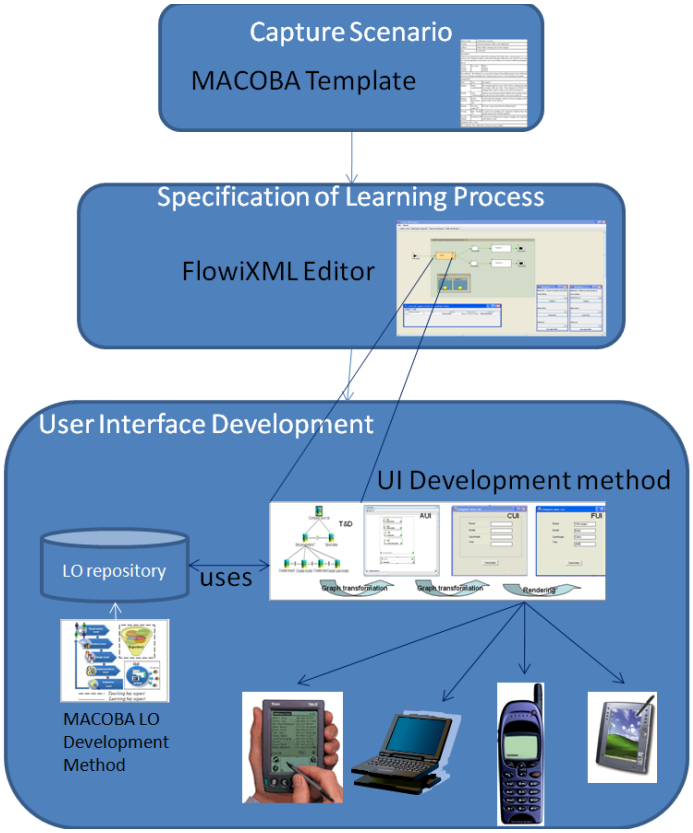

Fig. 4. A Method to generate User Interfaces for a Learning Management System (Source: [23]).

The knowledge base is used by the "Formal rules compiler" to load and parse the rules. Once this internal structure is created the tool performs a data analysis of the UI, encoded in UsiXML, which may be developed in a UsiXML editor. The UsabilityAdviser search for violations of rules formalized through the automatic evaluation of UI data. Finally, a report of the found violations of ergonomics and accessibility is presented. One major challenge is to create and update the knowledge base on ergonomic rules, which requests a complete review and compilation of existing rules from different sources. These rules are often expressed in a natural language that is normally more complex and open compared to a programming language. Anyway, the UsabilityAdviser provides an extensible way of evaluation from multiple sources of guidelines for (parts of) a UI.

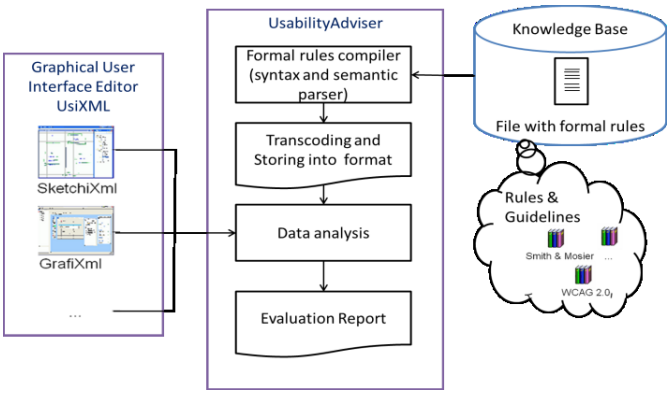

Fig. 5. Global process for automatic evaluation.

4 Conclusions

This paper presents a formal methodology to design an e-Learning for multicultural learning objects. A learning process is described as a workflow model that is composed of tasks, resources and places where education takes place. The goal of using the methodology is to provide the design knowledge to develop an eLearning Management Systems that addresses the current needs of e-Learning systems, including: gamification, multicultural, social networking, formal definition of learning process, multi-user support, multi-environment use, and multi-device. We propose to rely on a model-based engineering approach for at least two reasons: first, it enables structuring the development life cycle of learning process in a principle-based way (guidance support); second, the final rendering of UI for multi-context environments is desirable.Ergonomic guidelines are taken into account in the proposed solution, since its good design will allow for easy use. The future of this work is to develop the proposed solution.

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