Towards an Adaptive competency-based learning System using assessment

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Abstract

E-learning is not restricted to publishing online content. The challenge is to apply pedagogical models using new information and communication technologies in order to adjust the learning process. This adaptation will take place by proposing an adaptive learning system. There are several e-learning environment adaptation approaches such as adaptive hypermedia and semantic web. In our proposed system, we focus on evaluation that has not been, up till now, given its real value in the e-learning environment. The purpose is to implement an adaptive learning system for individualized pedagogical paths through a personalized diagnosis of learners' performances. This proposed system relies mainly on assessment and the competency-based approach as a framework. To achieve this goal, we adopt an enhanced cycle of formative assessment while adhering to a service-oriented architecture.

The system will be implemented as an activity in a pedagogical scenario defined responding to the learner's needs, while aligning with norms and standards

Keywords: *E-Learning, adaptive learning system, Service Oriented Architecture, formative assessment, learner model IMS-LIP, IMS-LD, IMS-QTI, IMS-RDCEO, LOM*

1. Introduction and context

Online education does not substitute the traditional mode and is not restricted to the publication of online content. E-Learning aims to improve the quality of education by providing an interactive environment integrating pedagogical goals and benefiting from advances in ICT. Our proposal seeks to implement an adaptive learning system based on a new approach, namely the assessment that has not been, up till now, given its real value in the e-learning environment. The proposed system relies mainly on assessment and the Competency-based learning. The purpose is to individualize the learning path through a personalized diagnosis of the learner.

Currently, competency-based approach (CBA) is at the heart of the curricula of most educational systems. This approach rests on the notion of competency, which has been formalized for implementation in e-Learning environment

Learners have different objectives and predispositions. Thus, an optimal learning path for one learner is not necessarily the same for the other [1]. Consequently, adapting learning paths is crucial to manage learner differences. However, to achieve this adaptation, many approaches can be considered. In our previous work [2]we were distinguished by proposing the implementation of formative assessment as a means to adaptive learning system.

To implement the proposed system in its environment, several constraints are to face. First, we model the competency and the learner according to CBA. Then, we consider assessment as an activity to incorporate into a learning unit. Finally, we design a bank of items (questions).

In our proposal, the enhanced formative assessment [3] is the approach that will lead to a personalized diagnosis. Thus, the proposed system offers a series of consecutively selected items. The correctness of the answer to an item determines the selection of the next one taking into account the previous responses and performances recorded in the learner model. As far as the technical context is concerned, we adhere to our research team's vision [4] making the service oriented architecture (SOA) the approach of integrating the e-learning framework. Consequently, the evaluation service will be implemented as a composed service.

To enable reuse and operability, the environment will be designed according to standards, such as IMS-LD, IMS-QTI and IMS-LIP.

The next section deals with the pedagogical scenario, complying with IMS-LD standards, which describes a learning unit nurturing our proposed service. Section 3 concerns CBA learner modeling that will interact with the proposed system in alignment with IMS LIP specifications. The two ensuing sections (4 and 5) tackle the personalization of E-learning path, taking into account the learner's performances and relying mainly on formative assessment. SOA, the choice of which is justified in section 6, will lay the ground for the developing of the proposed system (section 7), and we terminate with a conclusion and perspectives

2. The pedagogical scenario

The advent of new information and communication technologies (ICT) in education calls upon the various actors involved in the education system to rethink the instructional design to keep up with this technological revolution. This design was focused on the content and the learning object was the main element. For a long time, almost all research centred on standardizing descriptions of learning objects enabling their reuse and interoperability. But this approach is insufficient to meet the different learning situations. To complement these shortcomings and enable effective integration of technology in education, research has focused on modeling the teaching/learning situations highlighting activities rather than content. Pedagogical scripting is a central process in instructional design, which aims to define the organization of learning activities [5]. The scripting begins with content design, resource organization, activity planning and orchestration in an environment. The notion of learning activity is central to the scenario. According to Paquette (2007) a lesson plan is an ordered set of activities governed by the actors who use resources and produce results [5]. The scenario creates the conditions for an activity once it is operationalized using a variety of services and content. This script is possible by using an Educational Modeling Language (EML)

Educational Modeling Language: IMS LD standards

According to the European Committee for Standardization, an EML is "information model and aggregation semantics, describing the content and processes involved in a learning unit in a pedagogical perspective and in order to ensure reusability and interoperability" [6]. The EMLs propose formalisms for describing situations of learning mediated by ICT. Several proposals exist; that of Koper [7] sets the goal to describe learning situations with EML to define the relationship between the competence or educational objectives, activities and actors of learning. This proposal was formalized by the implementation of an EML which first inspired the IMS Learning Design (IMS-LD).

IMS-LD specifications (Fig. 1) offer a conceptual framework to model a learning unit using the educational concepts necessary for its formal description. This specification combines, according to Anne Lejeune [8], genericity of the implementation of different pedagogical approaches and a precise description power, while ensuring the exchange and interoperability of learning materials in the learning units.
The terminology used to describe a learning unit is borrowed from the theatre area, particularly the concepts of play, act, role and role-part. The involvement of different actors in a learning unit is described and organized according to a scenario, using an environment.
In our proposed adaptive learning system, formative assessment is an activity (according to IMS LD) integrated in a learning unit. In alignment with IMS LD standards, the

Fig. 1 The activity according to IMS-LD specifications [9]

assessment activity concerns actors and uses an environment composed of resources and services, to produce results. IMS LD does not impose a pedagogical model, it is a pedagogical meta-model. The choice of IMS LD is motivated by references to this specification by valuable works on the e-learning environment [10, 11] as well as recent efforts to implementations in many instructional design, and the developing of several tools for modeling and implementing learning scenarios such as Reload, CopperCore and CopperAuthor.

3. Modeling the learner in CBA

3.1 Learner modeling

In CBA, the learner is central and the learning environment must take into account his needs and expectations for the acquisition of a competency.
Learner modeling is a representation of the state of competencies. It focuses on learner characteristics and activities. It should represent information characterizing the learner at the static level (profile) as well as at the dynamic level (progression). In our contribution, the learner model is solicited in different stages of the

proposed system. It will help to highlight the root causes of the competency gap. This is possible by providing the items suited for a relevant diagnosis. The learner model can be implemented using standard templates. In our proposal, we adopt the IMS learner Information Package (IMS-LIP) specifications, which toes our vision that consider CBA as reference

3.2 Modeling learner using IMS-LIP

To ensure the provision of competence-based learning services and facilitate the interaction with the learner, it is necessary to record his individual competencies in a persistent and standard way. Thus, the learner can find learning activities that meets his needs to achieve the desired competencies.
In our proposed system, we adopt the IMS-LIP specifications, which are “based on a data model that describes those characteristics of a learner needed for recording and managing learning-related history, goals and accomplishments” [9]. That model defines an XML structure (Fig.2) for data exchange between different learning systems involved in the learning process.
The IMS-LIP model offers the opportunity to refer to a competency described in an external source using the tag <exrefrecord>. This competency description must allow performance measurement. Thus, we expand the definition with the HR-XML model.

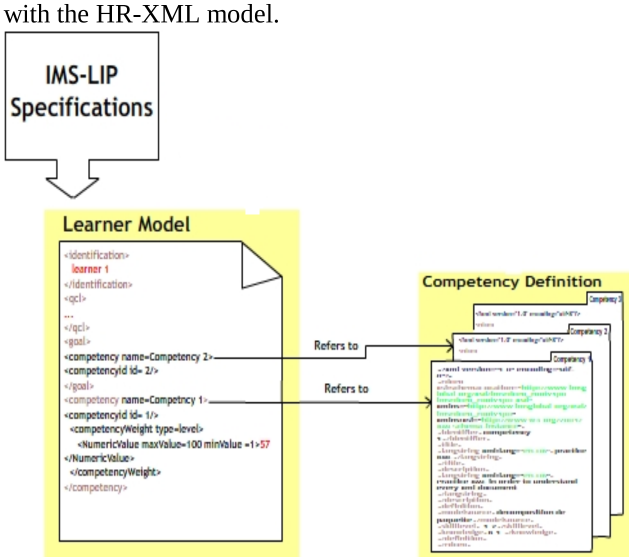

Fig. .2 Learner model using competency definition [6]

4. Personalizing learning: A content perspective

In aboard manner, personalization aims to adapt contents and services offered to the user to promote the quality of his interactions with the system [12]. In the education field, adapting is providing each learner with the feeling that the training is designed specifically to meet their expectations taking into account their capacities. According to Bellier [13], personalization targets the provision of learners with a training course perfectly suited to their level and needs. However, adaptation is based on identification of the learner, his ability, prior knowledge and current performance for the acquisition of competency. To do this, we stipulate that two ingredients are essential, namely learner modelling and a relevant diagnosis vis-a-vis the current activity. In this perspective, we modelled [14] formative assessment to offer to the learning system a relevant diagnosis customized to regulate the learning taking into account the characteristics and progression of learner. In our proposal, it would be prominent to operationalize formative assessment by describing the interfaces of its various functional components and their choreography to enable individualized diagnosis.

4.1 Referencing educational resources using LOM

The dynamic composition of learning paths (including assessment) is assembling a set of activities combining learning objects and services). The purpose is to draw for each student, the optimal path to acquire a competency (Fig.3) responding to the specific needs and the output profile desired by the educational system.

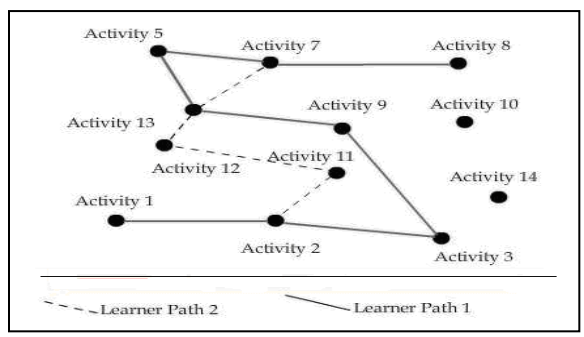

Fig. 3 The dynamic composition of learning paths using the proposed system

The production of learning objects is time-consuming and costly and can be made profitable when reused as long as possible. For this, it is necessary to specify the structure and index them [15]. The referencing of learning objects is a necessity if we want to integrate them in a course while maintaining its coherence and relevance. It is very useful for designers of educational content to adapt the choice of

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educational resources based on the specified requirements [16]. In this connection, they must add semantic information which should be structured, usable and descriptive of the resource and its use. The latter is metadata: data describing data [17], that Bernes-Lee, T [18] defined as "data about data" and considers that "Metadata is machine understandable information about web resources or other things". To enable operability and reuse, a standard must exist so that the educational content developers and users use the same repository. This repository can take various forms: Metadata standard (IEEE LOM (Learning Object Metadata) [19], DC (Dublin Core), taxonomies, ontologies formalized in various languages (XML, RDF, OWL). In our proposal, we will opt for LOM.

4.2 Learning objects for assessment: Question & Test Interoperability specifications (IMS-QTI)

On the occasion of an evaluation activity proposed as part of a pedagogical scenario, items will be administrated to the learner. This uses an item bank described in a formal and standard way. Each item corresponds to a competency and will be integrated into the environment of an activity. There
may be several items assessing the same competency.
In the proposed system, we opt for the standard IMS-QTI, which allows representing the data structure of a question (item) and a test (assessment) and their corresponding results. This representation is done through an XML file (Fig.4) providing interoperability

```
<?xml version="1.0" encoding="iso-8859-1" ?>
- <test>
 - <question ident="1">
    <duree>20 s</duree>
    <objectif>comprendre les base xml</objectif>
    <condition_prealable_a_question>connaissance en xml</condition_prealable_a_question>
    <condition_denvoi_de_reponse>r1.checked or r2.checked or r3.checked or r4.checked</condition_denvoi_de_reponse>
  - <presentation label="exemple de question" xml:langage="fr">
   - <flux>
    - <materiel>
       <mattext>qu'est ce que le XML?</mattext>
      </materiel>
    - <reponse_lid ident="001" rcardinality="single">
     - <choix_de_rendre>
      - <flux_label>
       - <reponse_label ident="1">
        - <materiel>
           <mattext>un langage de balise tout comme HTML mais avec une plus grande possibilité d'adoption</mattext>
          </materiel>
         </reponse_label>
       - <reponse_label ident="0,5">
        - <materiel>
           <mattext>un langage de programation</mattext>
          </materiel>
         </reponse_label>
       - <reponse_label ident="0,75">
        - <materiel>
           <mattext>une base de donnée amovible</mattext>
          </materiel>
         </reponse_label>
       - <reponse_label ident="0">
        - <materiel>
```

Fig. 4 Example of an item complying IMS-QTI

5. Formative assessment in CBA

5.1 Formative assessment

In an educational system, evaluation is central in the learning process. Its role is not limited to certification, which was the only outlet, but can be perceived as a process of verification to guide the teaching/learning process [20]. Therefore, it is necessary to distinguish between assessment as an integral part of the learning process (formative) and assessment for certification (summative or certification). In our proposal, we adopt the formative assessment as a component that participates into the process of learning.
The concept of formative assessment was introduced by Scriven, M [21] and supported by Bloom, B [22], when he built his model of mastery pedagogy [23]. According to Perrenoud [24], formative assessment helps the student to learn. In other words, it participates in the regulation of the learning process.
According to the review of literature, formative assessment is made up of a cycle that is built on three layers and that we enriched with pre-regulation layer [25]:
a) Observation: Establish the position in relation to a repository, instead of confining the learner to be on a scale and compare him to other learners.
b) Intervention: identifies symptoms to address root causes of problems. It involves analyzing metacognitive knowledge [26]. It involves identifying mental functions and highlights their weaknesses.
c) Regulation: Describe the mechanisms that provide guidance, control and the adjustment of cognitive activities, emotional and social as well as their relationship with a learner [27]

5.2 Competency: object of evaluation

Competency is abstract and hypothetical [28]. Thus, how can it be the object of assessment? The evaluation is the most problematic point of CBA [29], since it is not only assessing the situation in academic knowledge, but also mobilize, in a situation sometimes close to real life, resources, skills and competencies. In our proposal, we focus on formative assessment to regulate the learning process in a competency-based approach. This requires modeling competency from an operational viewpoint. In this way, we adopt the generic skills taxonomy of Paquette [30] and his definition of competency in which competency is defined as a relation linking three areas: knowledge, skills and actors.
In order to support and integrate competency in education, there is a need to provide reusable definitions of competence, across the different systems (CEN/ISSS CWA

15455, 2005). Several models are proposed to describe the competence formally, such as the IEEE Reusable Competency Definition (IEEE RCD) [31] and the IMS Reusable Definition of Competence or Educational Objective (IMS RDCEO) [32] specification In our system, the competency has been defined in accordance with the standard IMS RDCEO (Fig.5)

The IMS RDCEO specification defines an information model that can be used to exchange these definitions between different systems [6]. It describes the competency independently of the context and guarantees the interoperability among systems using the competency definition. The specification presents competency information in five categories: identifier, title, description, definition and Metadata.

IMS RDCEO specification permits the representation of the competency level, the success threshold of a competency and the complex competency within the title element in an unstructured format, thus, the machine can not understand, search and process this element effectively. Consequently, the scope of interoperability among different systems will be limited.

To define a common meta-model for the description of competencies, integrating; competency level, the success threshold of a competency and the complex competency .we propose possible extensions to the information model by its enrichment through HR-XML standard according to the recommendation of European commission of normalisation [6].

The HR-XML consortium was established to create a standard facilitating the exchange of competency information among different systems dealing with competency offering the organization a tool to enhance human resources activities

HR-XML describe competency in nine categories: Name, Description, Required, CompetencyId, TaxonomyId, CompetencyEvidence, CompetencyWeight, Competency and UserArea

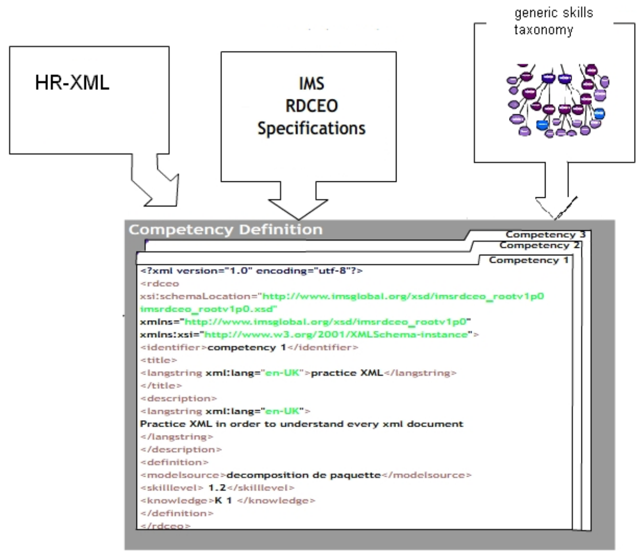

Fig 5 The proposed competency definition used in our proposed system

6. An SOA vision of e-learning platform

The implementation of an e-Learning system faces two major difficulties: (1) the modeling of pedagogical goals and operationalization of designed artifacts [4]. Thus, it must take into account the pedagogical context and the accelerated evolution of information technology. Currently, many e-Learning platforms existing in the market carry the teaching goals with features that are similar. The reuse of functionality and interoperability across different systems is neglected compared to the efforts concentrated on the structuring and reuse of learning objects (LOM, SCORM, etc) [33]. In our research team, the reuse and interoperability of components and services among different systems are in the agenda. The objective is to develop an open platform for the development, integration and management of distributed software components. In this perspective, our team adopt an approach of modeling the different components that we operationalize by enrolling in a service oriented architecture to reorganize the e-learning system (Fig.6)

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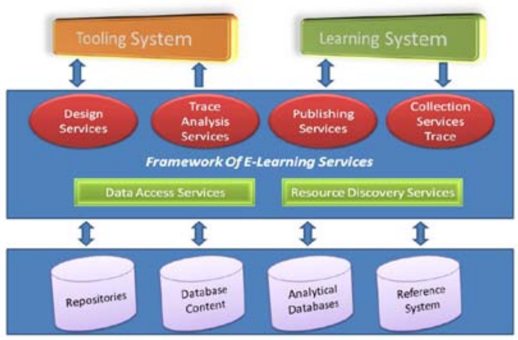

Fig. 6 The Adopted Computer System Architecture Integrating e-learning [4]

7. The proposed model

7.1 Modeling

To illustrate the progress of the evaluation process implemented in the proposed system, we propose the following flowchart (Fig.7)

Fig. 7 Flowchart explaining the progress of the activity of evaluation implemented in the proposed system

7.1.1 Constraints of the implementation:

In the process of implementing the assessment system modelled in our previous work [25], the major difficulty is to take advantage of ICTs while faithfully reproducing didactic goals. In this process, we must consider several parameters involved in the scripting of the e-learning unit (Fig. 8)

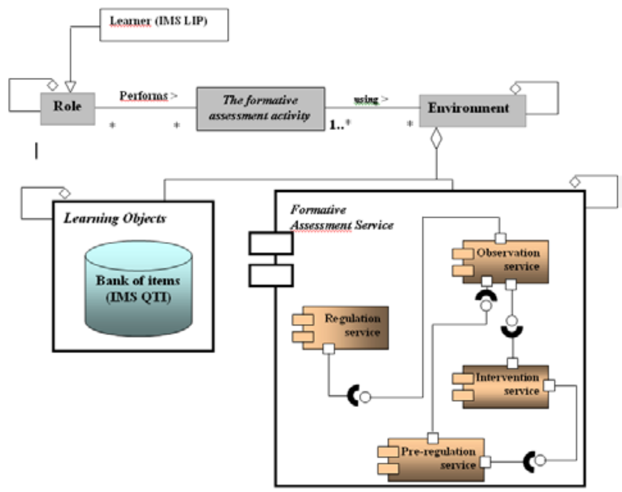

Fig.8: The environment of the formative assessment activity (according to IMS LD) in a pedagogical scenario complying with the IMS-LD specifications

The assessment activity (according to IMS LD specifications) will be operationalized in a pedagogical scenario; it uses an environment consisting of resources (according to IMS-QTI specifications) grouped in an item bank, and a composed service. The service integrates a formative assessment approach.

Several constraints must be respected when implementing the proposed services:

1) Reusable definition of competency to support and integrate competence across different systems. In this way we adopt the IMS RDCEO specifications.

2) Items must incorporate the notion of competency respecting generic skills taxonomy to construct and classify the items in terms of their difficulties, and permit reuse regardless of any platform. In this stage, we adopt the IMS-QTI standard for the implementation of criteria and performance indicators to measure the level of actual performance in the observation process. The target level is determined by the output profile

3) The unit of learning that will incorporate the designed activity and provide a pedagogical scenario. In this way, we adopt the IMS LD specifications.

4) A representation of the state of the learner's competencies as a prototypical perspective (learner profile) and a dynamic perspective (progression of the learner). For its implementation we have opted for a IMS-LIP standard.

7.1.2 Services and their interactions:

The proposed service consists of a set of services whose functions are synchronized to allow a personalized diagnosis proposing remediation activities. Thus, we find in (Fig. 8):

1 Observation service consists of a set of activities (Fig.9). The purpose of this step is to establish the state of knowledge and skills. At this stage, we calculate the level of performance (current) using criteria and indicators of performance to identify the competency gap.

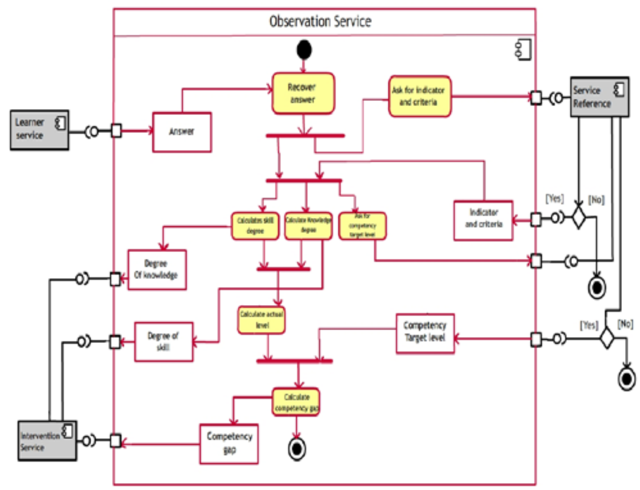

FIG.9: Observation Service activity

Operationally, through this observation stage, the following steps are crossed:

a-The learner gives an answer to an item designed according to IMS-QTI, and the result will be forwarded to the observation service.

b-The observation service identify the current competency level using the item and the learner answer

c-The observation service interacts with the output profile to extract the target competency level, and accepts as inputs: the item, the response of the learner and the target competency level from the output profile. In the output, the observation service results in the competency gap (Tab.1),

Tab. 1: competency gap [31]

State	Awareness	Familiarized	Mastery	Expertise
Value	0 2.5	5	7.5	10
Competency A				

Current level of performance
Competency gap
Target performance level

2 - Intervention service: In this step, it analyzes symptoms to address root causes of the competency gap detected in the observation step. It involves analyzing metacognitive knowledge (the mental) which remains very mysterious [26]. Assessing competency based on observing only reaches limits very quickly. Say "you can do better" does

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not help the learner to know how. To be useful, we must identify, isolate mental functions (generic skills), and highlight their weaknesses.

Operationally (Fig.10), (a) the process begins by intercepting the competency gap calculated in observation step and the current level performance.

b- If the competency gap is not tolerated, the intervention service consults the learner model. It compares the current level (intercepting from the first step) with the performance level carried in the learner model for the same generic skill.

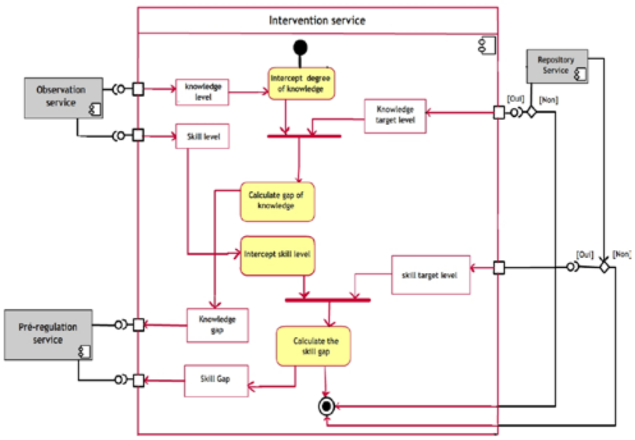

FIG.10 : Intervention service activity

3 - Pre-regulation service: in this step, we adapt the evaluation to the learner by providing items suitable for his current competency level. The purpose is to make accurate assessment with fewer items.

In this stage, the principal role is to select the optimal item based on parameters from the previous step

The pre-regulation process uses a bank of item semantically referenced and each is relative to a competency. The items are designed according to IMS QTI specifications and the evaluation is given item by item. The item is chosen in the pre-regulation stage. The bank of items will be used until the end of the assessment. Once the assessment is completed, the final competency gap will be used in the last process to choose the next learning activity (Fig.11)

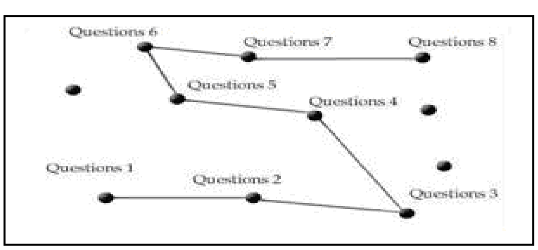

FIG.11: Individualization of formative assessment through the personalization of evaluative path for each learner

4 - Regulation Process: In this step, a mechanism that provides guidance and adjusting learning activities will be implemented and its main role would be to choose the remediation activity that is the most suited to the learner for the acquisition of competency

7.2 Implementation

Service oriented architecture

The goal is to provide "an open Platform" for the development, deployment, interaction and management of distributed e-services. [34]. The model of web services (Fig.12), is defined as an architecture calling upon a set of standardized protocols (fig 6). The Orchestration of services is carried out by IMS LD specifications.

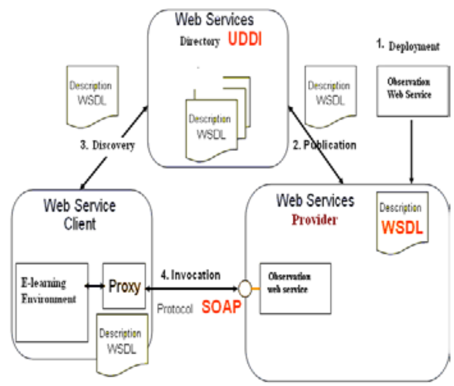

Fig. 12 SOA and observation web service

The environment:

Figure 13 illustrates the environment of our proposed system:

Output Profile: the profile desired by the educational system. In implementation, it is considered as an XML file recording for each skill level targeted.

Learner model: it is specific to each learner is an XML file that records the level of performance for each competency

Issues that will be delivered to learner described through an XML file, while respecting the standard (IMS-QTI)

Competency definition that describes the skills that will be used both by the output profile as the model of the learner

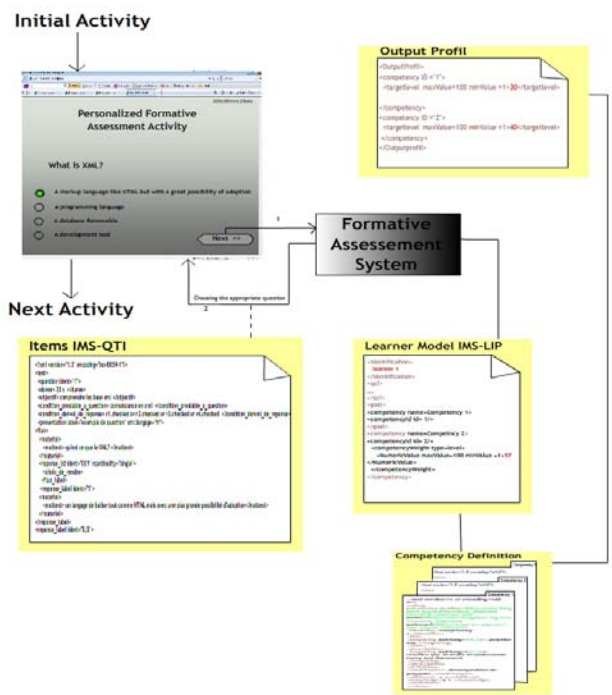

Fig. 13 the specification of environment of the proposed system

8. Conclusion & perspectives

To provide an interactive environment tailored to the learner's needs is one of the most important goals of e-learning environments. Interactivity and adaptation do not rely solely on technical artefacts, but are the result of a combination involving educational theory, and technological advances in the field of ICT. Several studies have addressed the individualization from different angles. Ours is different, both in the approach and tools; it offers a system that individualizes the evaluation process offering a personalized diagnosis to decide upon the remediation activity. In the implementation of the proposed system, interoperability and reuse justify the choice of components and the environment interacting with the system. As far as the technical architecture is concerned, we adhere to our research team's global vision. In this vision, the e-learning platform should be composed of a set of reusable, interoperable and interacting services. The composition and the orchestration of these services will be allotted to the ILMSD standards in the learning unit framework.

Formative assessment is undoubtedly a central concept in the process of teaching/learning. Its implementation in the context of competency-based approach in the E-learning systems allows the individualization of learning.

Several perspectives are considered, and can be summarized in:

1) The developing of the services which make up the system.
2) The deployment and testing in a learning unit.
3) The collecting and analysis of formative assessment activity traces.

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