A Framework for Competence based e-Assessment

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Abstract. In recognition of changes to the typical patterns of working life, Higher Education in overall the world is currently laying great stress on Competence-based learning. Nevertheless, while lifelong learning is increasingly influencing university and workplace in overall the world, some critical issues still have to be worked out so as to reach its full potential. Since, it appears to address the assessment expectations of these competences. This concern has not been sufficiently investigated and only a minority provided some efforts to grant the fundamental models to assess Learners based on the standard required competences. Thus, we propose in this work our semantic model for competence-based assessment to support the formal and informal learning competences visibility. As well, we provide a high level sub-models architecture. This framework is carried out through the use of Web Services. The experimentation results support our research goals.

Keywords: Competence, Formal Model, Lifelong Learning, Competence Web-Based Assessment, Non formal and informal competence-based learning, Web services.

1 Introduction

Broad interest in competence development can be identified in current research. A core problem is to reconcile increased productivity with high quality. Several researches try to find these issues reasons and tackle some solutions. Typically, a common approach to enhancing this field involves recognizing human factor as the main key associated to its development. In fact, one of the industry concerns is related to the development of its human resources talent because the quality and innovation of its products and services depend to a great extent on the knowledge, ability and talent applied by software engineers through the software development process [23].

The continued growth and importance of this issue is shaping the new learning environments, posing new challenges, fostering the need for new models and approaches both at the learning and assessment levels. Hence, we are now confronted with the challenge to accomplish the initiated shift to a competitive and competence-based community in order to guarantee productivity and high quality. To attain such

ambitious goal, learning has to fundamentally move from input-based to outcome-based approach. Nowadays, technological, economic, and organizational changes entail new needs for an educational system more responsive and open to the labor market's requirements. To meet the challenges of worldwide increasing competition and to improve the employability of graduate students, education should provide learners with not only knowledge, skills, and competences but also with the proof that these learners could reveal the competences they are supposed to perform in the labor market. Thus, promoting a more dynamic and future-oriented interaction between labor demand and education supply which is evidently the great challenge for the educational system. To establish this interaction, there is a need for mechanisms such as competence models and related assessment tools, which can be used for enhancing the fluency of the key competences of learning and assisting the development of a range of valuable services, e.g. personal and professional development, competence-based learning and employment opportunity exploration.

Although implemented in different ways, current learning management systems share a core common weakness: the assessment process is mainly knowledge-based. This paper presents a comprehensive analysis of competence/y based approaches in the existing literature. The results show that these approaches are far from being able to afford the learner with his valid acquired competence profile. Competence-based assessment is still insufficiently implemented or even not addressed.

Recognizing the inadequacy of current traditional knowledge-based assessment systems in higher education to achieve performance visibility, we need to rethink how we design new assessment models that can respond to the corporate requirements of the 21st century and mirror the learners' competences which are fundamentally technical and generic. The findings of the analysis are meant as a starting point for our work aiming at modeling and implementing a new assessment system providing learners with their acquired competences profiles.

Accordingly, we discuss in this paper academic Competence based assessment model; a formal model of assessment characterized by the convergence of lifelong, formal, non formal and informal competence-based learning. We then present the Competence Web-based Assessment Framework (CAF) that illustrates the proposed competence –based assessment model in action.

This paper is organized as follows: In section 2, we describe the theoretical background on the competential paradigm as well as the definition of the competence-based assessment; Section 3 presents our competence Web-based assessment model and reports on the framework specification of the proposed model through detailing its corresponding sub-models; Section 4 details our proposed Web Services-based framework for competence assessment; In section 5, we present the experimental results. Related works are presented in section 6, where a succinct analysis and comparison of related work and this paper is made; and finally section 7 brings the conclusions and future work.

2 Background

2.1 Competential paradigm

Though the rapidly increasing number of related work published in recent years, the theoretical grounding is still weak as a whole, especially in the introduction of concepts. In fact, the concepts of competence and competency are almost used substitutably without distinction. The major aim of this section is to recover the understanding of the theoretical background related to competency/e modeling. The study we present here follows up some previous works [12] [13] [14].

The HR-XML Consortium uses the term "competency" rather than "competence", stating that competencies are "measurable characteristics" [10], and making out that "some competencies can be objectively measured, whereas others may only be subjectively recognized". The competencies are discerned by their types, the most common are regarded as: basic, generic and specific. The components are broken down into three levels such as: general competency, the unit of competency and elements of competency. The specification is, as the name entails, principally orientated towards business employment and recognition. Nevertheless it is easily adaptable towards educational and training contexts.

Though the competency definition has not reached unanimity over the years, competencies are commonly conceptualized as measurable patterns of knowledge, skills, abilities, behaviors, and other characteristics (KSAOs) that differentiate high from average or poor performance [24]. Fundamentally, we may regard the competency model as a set of success factors which contribute to achieving high performance and concrete results. The competency model is important because it provides a road map for the range of behaviors that produce excellent performance [25].

The work in [7] defines competence as a combination of knowledge, skills and attitudes appropriate to a given context. Competences are defined in Cheetam and Chivers [3] as 'overall, effective performance within an occupation, which may range from the basic level of proficiency to the highest levels of excellence'. The proposed definition does emphasis that the concept of competence is built on three dimensions:

- a person's competencies - knowledge, skills, attitude, or any psychomotor or mental activity which may require mastery [3];
- an occupation, which may range from hobbies and sports to professions; we prefer to use the commonly used term context instead;
- the proficiency level of a person with respect to a context; proficiency could be expressed by a collection of skills, by some revelation of appropriate behavior in the context, or by competences in related contexts.

As persons may have various occupations, they may have various levels of competence for each occupation. For instance, Ahmed might excel in his occupation as a software engineer, but his qualities as a networks engineer are mediocre. Yet, there is an overlap in the knowledge and skills required for both professions, and skills learned in the former profession might increase competence in the latter profession.

Key competences are considered those which all individuals need for personal fulfillment and development, active citizenship, social inclusion and employment [15]. As the work in [16] states, the model of competence refers to the cluster of competencies for a specific job, the grading behavior standard of each competency and its matching degree to a specific job.

In light of the differences in the core connotations of competency model and competence model, we argue that the two conceptions should be also distinguished and support the finding in [5] and [15] who put forward the concepts of "input competencies" and "output competences" and build on the fact that the term competence is seen as an output-based approach focusing on the requirements of a certain job profile and the term competency as an input-based approach correlated to the behavior that should be acquired to carry out the task or job.

2.2 Approaches to competence-based Modeling

Nowadays people are continuously learning everywhere and at all times. Accordingly, learners have numerous ways and opportunities to acquire and gain competences throughout their lives. It is very likely that this learning, taking place at home, within training systems or elsewhere, is a lot more significant and relevant than the kind of learning arising in formal settings. However, this kind of learning happening outside the formal learning system is not appropriately valued. From this perspective, engaging learners with competence-based development has become an important challenge. One popular approach to meet this challenge of engaged competence-based development is the so-called open and lifelong learner modeling.

Furthermore, these learners have a variety of options to keep these learning outcomes in digital formats. Particularly, electronic portfolios (e-portfolios) are being widely used in higher education as a key part of an e-learning management system.

The goal of this section is to explore some of the learner modeling challenges associated with competence-based assessment. We introduce potential benefits of open and lifelong learner modeling from a competence-based perspective.

Open Learner Modeling

To become effective, a competence-based assessment system must have a more accurate and complete understanding of the learner. To increase this understanding, the assessment process should fall under the control of the learner. One approach to allow that is to use open learner models. Open learner models are defined as student models that are accessible to the learner being modeled or possibly to teachers, peers, or others who may be able to enhance the model [8]. It's argued in [23] that, in addition to improved accuracy, open learner models are thought to enhance metacognition, motivation, and collaboration and/or competition. Learners may access data, add reflections, and edit, etc. which may ultimately enhance their trust in the system. Increasingly, learner models are being opened to learners as a means to encourage them to engage in their own competence-based development. In fact, a range of benefits have been reported on opening the student models to the learners,

such as increasing the learner's awareness of the developing knowledge, difficulties and the learning process, and students' engagement, motivation, and knowledge reflection [2] [19] [28]. For those reasons we think that open learner models are the key components of competence-based assessment systems since they guide and reflect the assessment process.

Lifelong Learner modeling

The assumption behind the lifelong learner modeling is that all learning has value and most of it deserves to be acknowledged through the learner model. It is a likely option to formal higher education to have non-formal and informal learning activities represented and assessed. It is also likely to afford an open learner model to support self-directed learning and interpret learner information from different tools. A key challenge is the ontologies necessary for understanding information from various sources.

2.3 Competence based e-Assessment

Competence-Based Assessment is the process of assembling evidence and building judgments on whether competence has been reached. The aim of such an assessment is to verify that an individual can act upon the standard expected in the workplace, as expressed in the related approved competence standards. The authors in [9] describe the competence based assessment as a "form of assessment that is derived from a specification of a set of outcomes; that so clearly states both the outcomes — general and specific — that assessors, students and interested third parties can all make reasonably objective judgments with respect to student achievement or non-achievement of these outcomes; and that certifies student progress on the basis of demonstrated achievement of these outcomes. Assessments are not tied to time served in formal educational settings".

In the traditional learning, assessment is usually based on knowledge through objective evidence or essay. In the competence-based learning, assessment could be based on competence rules if any, but mainly in the evidence testing through demonstrations, product design, simulations and portfolios.

3 Competence based e-Assessment proposal

3.1 Competence based e-Assessment model

The figure 1 provides an overview of the proposed model. The assessment model is detailed in [11]. It could be translated as follows: A Learner has a Competence Profile which is composed of competences. Each Competence Item consists of a Competency that he/she performs in a given Context with a mastered Proficiency Level. Every Competence is argued by some Evidence. These evidences are the proof of an

Assessment Test which is comprised of a set of Weighted Assessment Items. Each Assessment Item is conceived to address one or more competences. To deliver the appropriate Feedback, the Assessment Test uses an Assessment Grid which is based on Assessment Criteria and Assessment Rules.

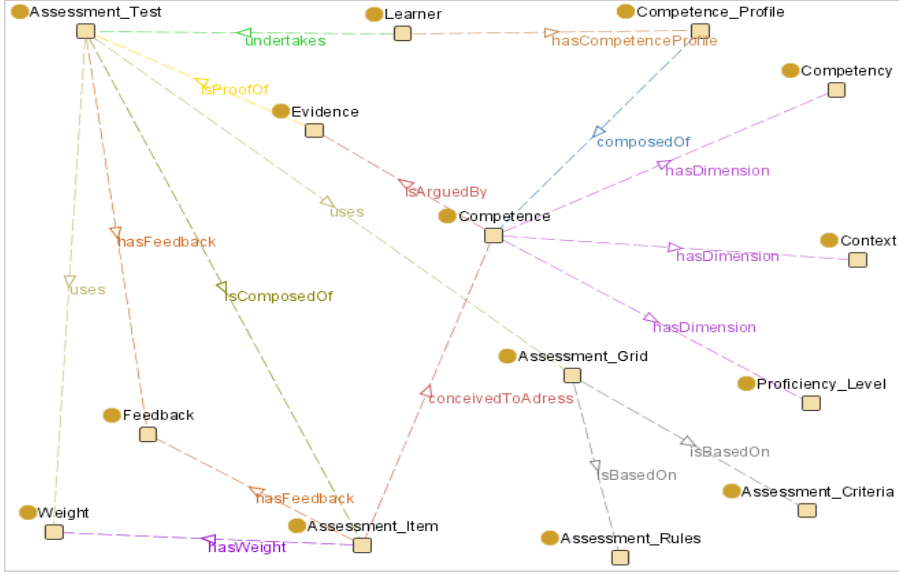

Fig. 1. Competence Web-Based Assessment Model [11]

Though some blueprint do exist, to the best of our knowledge there has been no prior explicit formulation of this model, nor a concrete application or empirical assessment, as presented in this paper. It supports the awareness of employability competence-based requirements by detailing the learner's acquired competence profile so that it becomes clearer and easier to judge the convenience of the graduate learner to the proposed posts. It provides a powerful framework for support of both learners and stakeholders.

3.2 High level sub-models Architecture

Our competence Web-based assessment model consists of the following components: Learner Model, Domain Model, Rule Model and Runtime Model. Each one of these components is a logical group of model elements and is represented as a package, as illustrated in Figure 2.

The learner model holds information such as the acquired knowledge profile, the acquired competences and preferences. The domain model follows the specified curricula structure and could be adapted to further domains. The rule model is settled by the tutors through a set of formally predefined rules to meet the competence-based assessment process.

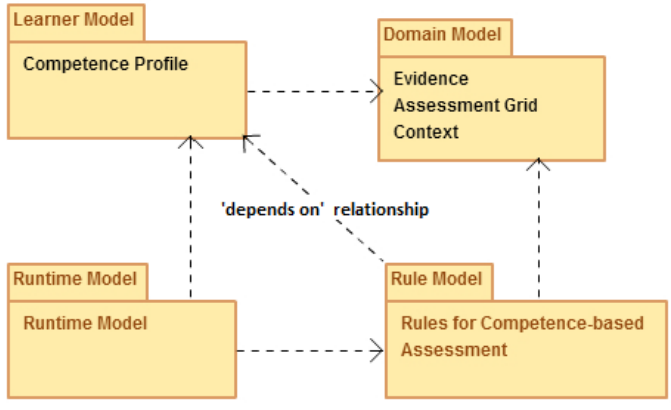

Fig. 2. High level sub-models architecture

4 Service Oriented Architecture for competence assessment

Current trends in web based assessment systems are towards flexible and scalable approaches that can be applied to a wide range of domains and can be further expanded to incorporate more enhancements.

Recently, Service Oriented Architectures (SOAs) have been used to build modular and flexible systems, and some research works developed new distributed e-learning and assessment approaches, such as SWAP-Learn [4]. The service-oriented paradigm has a universal support and is promptly gaining wide recognition within the industry since it relies on a simplified mechanism and uses open standards to connect distributed applications regardless of the technology behind. This empowers flexible orchestration of services through automatic selection, interoperation of existing services, and execution control. Further, it raises application performance, and reduces costs of deployment, testing and maintenance. Hence, we propose this architecture in figure 3 for competence based assessment in a cloud computing environment.

A detailed description of this architecture is available through a workflow in [14]. In this work, all functions of our competence based assessment scenario depicted in [12] are modeled as services. We present here the used Web services by providing the description and their interactions;

The login service:

The authentification of learners is accomplished through the login service, which checks the learner's identifications and transfers them to the other services.

The competence referential provider service:

This service has to provide the learner with a visualization of the existing competence referential.

The evidence analytics service:

This composite service adopts a learner-centred and lifelong learning-oriented approach to the collection of evidence. These evidences are later analyzed to fairly and reliably judge competences. It relies on the execution of both:

Evidence collection service; This service helps the learner to argue his decisions through providing the related evidence. He gathers evidence with regard to the picked competences through the self-assessment stage. This evidence could be from formal, non formal and informal contexts. This information is stored in his portfolio.

Evidence filtering service; The objective of this service is to identify which competences are effectively acquired among the picked competences. This relies on the confidence rating of the associated evidence. If the provided evidence is judged unreliable, the associated competence would need further demonstration to be validated. In such a case, the system affords an assessment test to check the related competence. The consideration of the "confidence rating" is currently an item of future work.

The connector service:

It is the mediator service. It enables communication between all other services, except for the login and competence referential provider services.

The competence assessment service:

This service is composed of two sub-services:

Assessment delivery service; after making decision on which competences need further evidence, the assessment delivery service is invoked to provide the learner with the corresponding assessment test.

Grading service; this service receives the response from the learner, evaluates it, assigns a score, changes the state of the related competence and sends the result to the connectivity service. The state of the related competence changes based on a set of logical rules and depending on the awarded score.

The acquired competence profile delivery service: Finally, after checking if the obtained results comply with the acquisition of the related competences, the acquired competence profile delivery service provides the validation of the acquired competence profile. The acquired profile includes all learner competences within formal, non formal and informal contexts.

Our proposed architecture of competence based assessment reflects flexibility and diversity, in which new aspects and services can be connected to afford a suitable level of personalization and therefore enhance the whole system.

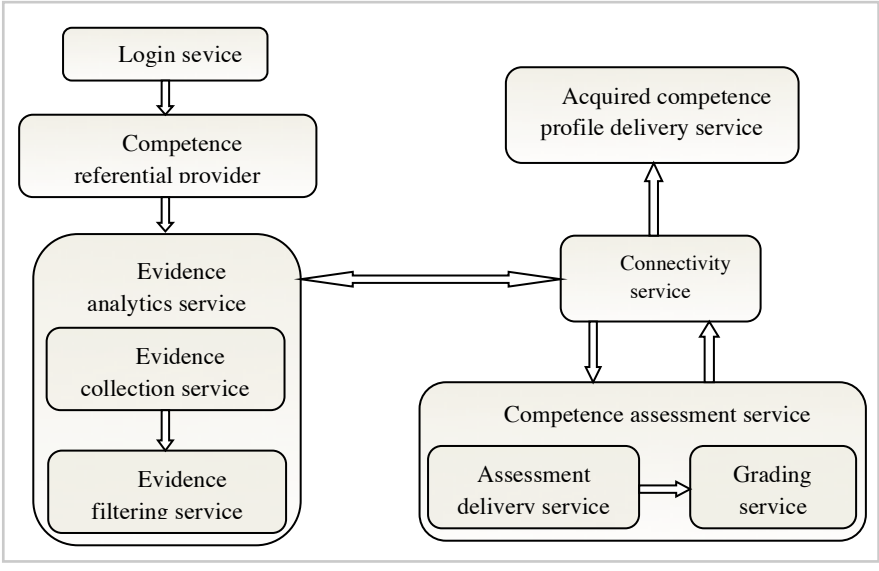

Fig. 3. Web services-based architecture for competence-based assessment

5 Description of the experiment and validation

5.1 Description of the Experiment

We proposed in the SWAP-COMP system to test the learners' competences level. This test is only possible in case an efficient and coherent competence modeling have been realized.

In this research we have established an ontology for "Computing and Internet Certificate (C2i)" referential [29] which is organized around five competence areas. This referential allows the acquisition of computer and internet skills. It certifies a first level of competence that can be extended with the C2i level 2. The choice of this referential is motivated by the introduction of qualification of ICT competences in higher education within all universities. This joins in the will that all the students would have this transverse certified competence, both for their successful study and for their future vocational integration.

We first set up the classes of concepts in this referential. We then looked for the subclass relations between these classes, which helped us to define the hierarchy of classes. The ontology that we created is used for the resource description of the "Computing and Internet Certificate (C2i)" referential on which we propose to test SWAP-COMP.

In figure 4 we present an overview of all the competence instances within the "Computing and Internet Certificate (C2i)" referential [29].

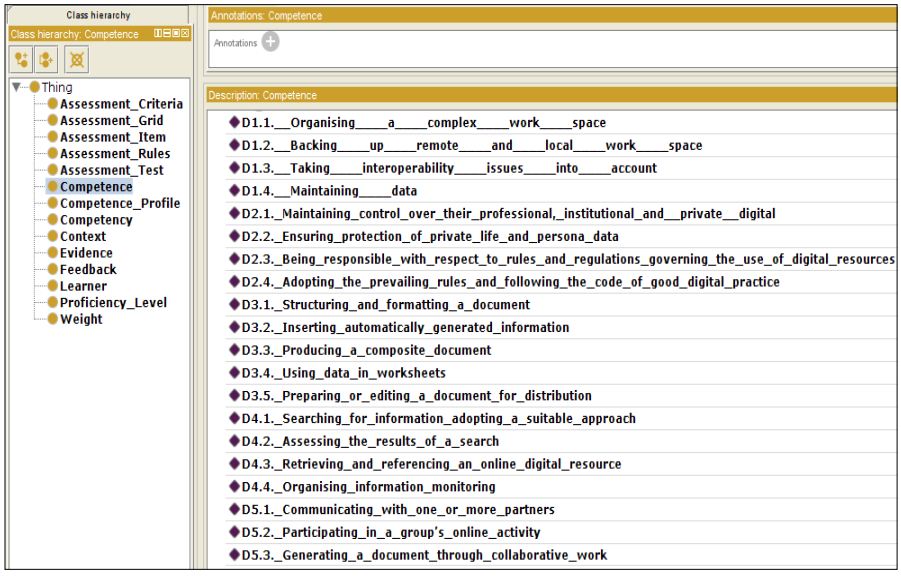

Fig. 4. Competences of the "Computing and Internet Certificate (C2i) level 1" referential

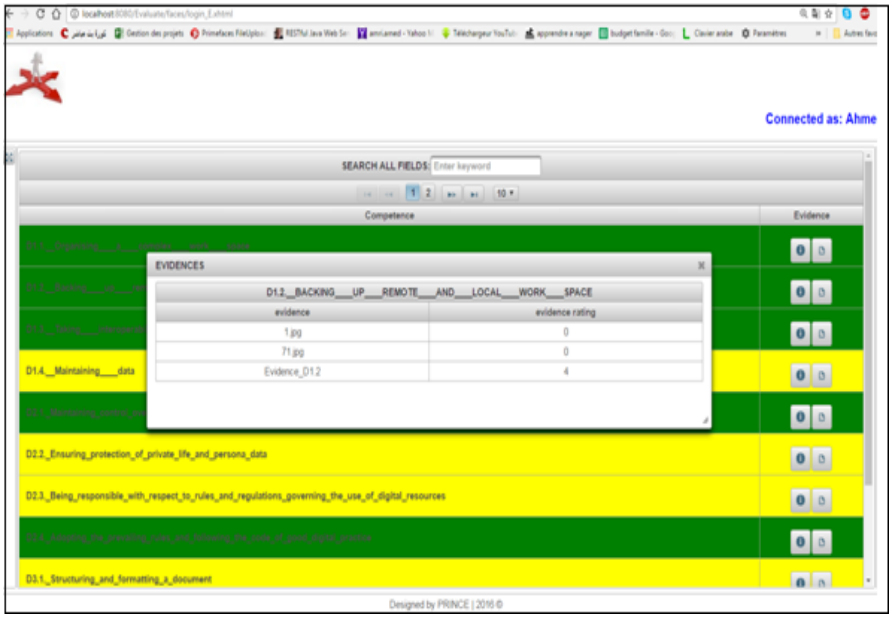

Fig. 5. Evidence collector interface

The learner, after signing up, is asked to pick out his potential competences in the competence referential. If available, the learner attaches to the Evidence Collector his related Evidence(s) as shown in the figure 5. This information is stored in his portfolio.

To accurately assess competences, we have to define indicators that could be extracted from the activity of each learner in the system. SWAP-COMP records each learner interaction: downloaded files and submitted assignments. For each competence the learner could attach up to three evidences.
For each evidence, a Confidence Rating (CR) is assigned by SWAP-COMP according to the table below.

Table 1. Attributed confidence rating with respect to evidence analytics

0: No evidence
1: Very weak: attests the related competence but with significant weaknesses
2: Weak: attests the related competence but with some weaknesses
3: Acceptable: attests the related competence satisfactorily
4: Good: attests the related competence with some aspects of high quality
5: Very good: attests the related competence with all aspects of high quality

This information is used as an indicator of learners' achievements as following: An evidence E is convincing in one of the subsequent cases:

- *CR>3 (One submitted file for evidence E)*
- *$\sum CR > 4 \rightarrow$ (Two submitted files for E={E1, E2}*
- *$\sum$ CR > 5 (Three submitted files for E={E1, E2, E3})*

After review of the provided evidence(s) in the light of the picked competences, SWAP-COMP skips over selected competences for which the learner has provided convincing evidence and find out what he should attest further. Decision on which competences need further evidence is made. The mandatory list of corresponding Competence based Assessment tests, to confirm whether the picked competences are really acquired, is then presented to the learner.

The final competence level is automatically attributed upon test completion. Therefore, it is:

- *Beginner/ Novice if $\sum$ Marks Awarded $\in$ [50..65] (Acceptable)*
- *Intermediary if $\sum$ Marks Awarded $\in$ [66..79] (Good)*
- *Expert if $\sum$ Marks Awarded $\in$ [80..100] (Excellent)*

5.2 SWAP-COMP evaluation

An evaluation of SWAP-COMP was performed, with a particular focus on usability and effectiveness aspects. We experimented it with two categories of learners: undergraduate students and lifelong learners. A panel of thirty learners with different competences profiles was selected; twenty of these were enrolled in the first year of a specialized education curriculum at the Higher Institute of Specialized Education (ISES) at the university of Manouba, and were expected to be part of the "beginners" and/or "intermediaries" category. The remaining learners had already finished their studies and were seeking for a job. They were expected to reach the "Expert level" in our experiment. In this evaluation each learner- without undergoing any prior training on how to operate SWAP-COMP- has used the system; at the end of the course session for the ISES students and in non formal settings (personal meetings) for the

others. This gave them the opportunity to navigate through the proposed services and answer some of the assessment tests. To accurately assess competences, we have defined indicators that could be extracted from the activity of each learner in the system. SWAP-COMP recorded each learner interaction: downloaded files and submitted assignments. This information was used as an indicator of learners' achievements.

The real time data were produced during the learners' interaction with the complete system. All the actions that learners performed with the components were recorded and tutors had the possibility to view them as reports. Additionally the scores obtained for the tests were stored within each modules and gradebook within real-time. Also the learner's competence profile progress bar was updated on a real-time basis.

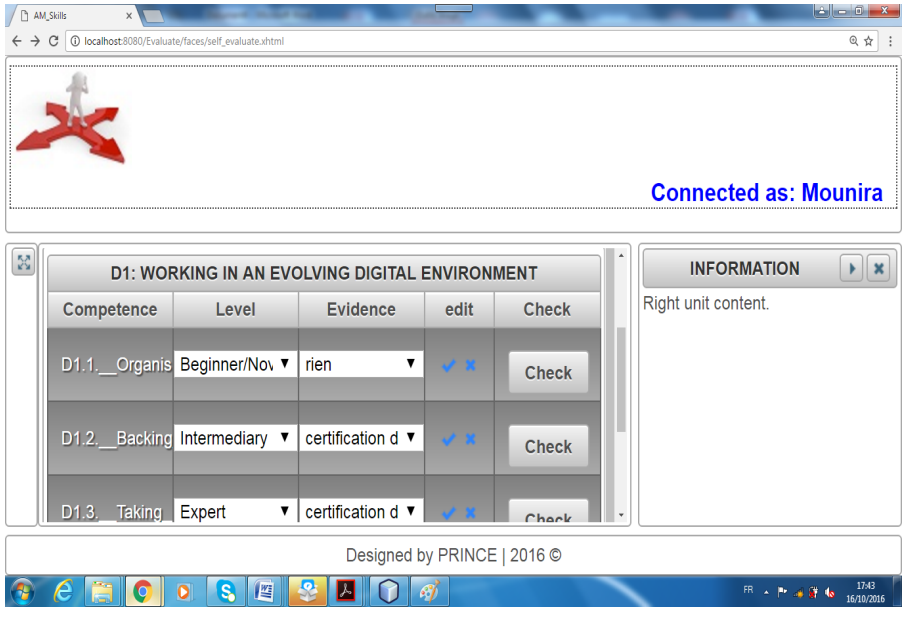

Fig. 6. SWAP-COMP self assessment interface

6 RELATED WORK

In this section, proposals having the same goal or theme of this work are described. Based on the amount of related works found, it can be affirmed that several initiatives on competency/e-based approaches have been carried out, from which relatively few works have dealt with competence Web-based assessment.

In [6], the authors describe an experience in building up and teaching Web engineering skills as part of the masters programme in software engineering at Aalborg University. The authors described how they have incorporated various training on Web engineering related topics into the software engineering masters

degree programme. The context in which this training happens is project oriented problem based learning. It's well argued that due to the inherent properties of problem based learning, this teaching style provides more competence based learning and deeper understanding required by industry and also necessary for those students pursuing a research career.

The authors in [22] address the issue of competency comparison, providing some heuristics to match the competencies of users with those involved in task-based scenario components (actors, tasks, resources). Competencies are defined according to a structured competency model based on domain ontology. The provision of the context for recommendation is done through a learning scenario model.

The work in [17] proposes a model for the study of personalized hypermedia systems with a competency approach. The competency model is used to adapt the course material to the student's needs. The goal is to help students learn and thus reach a suitable competency level.

The aim of the research in [21] is to contribute a competence-based system which recommends itself

to learners, in order to get appropriate study materials as links from the Web without communication from the teacher's side. The proposed model draws on the (COMBA) model [26].

A methodology supported by a technological framework to facilitate communication about informal learning between businesses, employees and learners can be also found in [8].This includes a cloud personal learning network, which integrates a portfolio system and institutional tools such as an institutional environment, a repository, and a competence catalogue. It allows the institution to draw formal and non-formal actions in light of the informal learning that is taking place, and to match students to others with similar interests according to their informal learning activities, interests, and development.

The Personal Learning Environment (PLE) project in [15] has showed that students do not possess all needed competences for self-organization, self-learning and self-cognition that would impact the effectiveness of their learning. The aims of the work are to explore the students' competences profiles and their capabilities for behavior activities to organize and plan learning according to a given learning situation and to examine the functionality of a PLE to facilitate the achievement of missing competences. A competences model for personal and professional development is created after a literature review of key competences for engineers and lifelong learners and after gathering the students' opinion through many surveys.

The work in [5] addresses the problem of competence representation and exchange. The authors provide a representation of competences, relationships among them and competence profiles. Such a model allows advanced algorithms for competence and profile matching. However and similarly to the former work, there is no information provided within the latter works to conceptualize the competence-based assessment process.

The authors in [20] introduced PALO (Personal Achieved Learning Outcome) a data model for capturing information that enables management and exchange of personal data on achieved learning outcomes (knowledge, skills, competences). The Personal Achieved Learning Outcome schema describes the relations between achieved learning outcomes, context where outcomes are achieved, and evidence

records of the gained learning outcomes. Information on levels like proficiency level of learner mastering for the learning outcomes are also captured.

In [1] authors present a formal knowledge representation model to define a competence-based student-centered education model. The aim of the assessment process is to determine the degree of realization of competences developed by students during the execution of some continuing education activity. The proposed approach uses ontologies as formal knowledge representation model to help teachers in developing an evaluation plan of education activities oriented to determine the degree of competence achievement. The model is composed of five main classes: Student, Assignment, Submission, Grade and Indicator.

Nevertheless we think that, similarly to the previous one, this model is rather educational oriented than assessment oriented as it doesn't include some relevant concepts related to the assessment process. As well, this work doesn't consider any distinction between the terms competence, competency and knowledge.

The above presented approaches stand for a step forward to the modeling of competence-based systems. Some of them address very well the issue of competency/competence modeling and achieve the tasks for which they were conceived with respect to the requirements specified by their authors. Nevertheless, we spot some drawbacks in each one of these approaches. While almost all these publications have made efforts to afford competency or competence models, only a minority provided some efforts to grant the distinction between the two concepts, of which and for the best of our knowledge no one provided appropriate assessment Framework based on the proper competence conceptualization.

7 CONCLUSION AND FUTURE WORK

In this paper, we addressed how the growing interest in defining higher productivity in real workplace requires a new approach to assessment in current educational systems. We presented a competence Web-based assessment model to respond to an internationally increasing competition. On this basis, the article reports on the framework specification of the aforesaid proposal through detailing its corresponding sub-models.

The proposed competence Web-based assessment model is a large step forward to effective support for lifelong learners in relation particularly to employability. Furthermore, we proposed a web services-based framework for the competence assessment that reflects flexibility and diversity.

Looking ahead, experimenting SWAP-COMP with different assessment scenarios thus to evaluate the reliability and flexibility of the proposal as well as to scale the features provided for the assessment process is presented.

This work opens several research themes and we can characterize the future work according to several main directions such as application of SWAP-COMP to other Competence domains and taking into consideration other kinds of assessment items within SWAP-COMP.

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