A Learning System Based on Learner Profile

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Abstract: The main purpose of e-learning systems is to provide learning materials through Internet to let learners upgrade their knowledge. To be more efficient, these systems must be able to present their learning materials based on learners' acquired knowledge as well as their learning capabilities (learning styles). Therefore, their development should be based on pedagogical models that make them able to adapt their learning materials on the bases of learners' competences (acquired knowledge and learning capabilities). This paper proposes a model and architecture of a learning system able to support pedagogical concepts such as learning styles and pre-requisite competences to adapt learning materials to learners based on their profiles.

1 INTRODUCTION

To improve their knowledge, many people use existing e-learning systems such as Moodle (Moodle). Unfortunately, these platforms don't offer learners' centred courses; therefore, most of the time, learners don't find a suitable ways of learning (learning style). It is noticed also that, the current platforms don't give much importance to the pedagogical side of the learning process; this can be seen through the used metadata model descriptor such as SCORM (ADL, 2009). However, many experimental research (Kolb D., 1984), (Chartier D., 2003) have noted that taking into consideration the pedagogical side of the learning process leads to better results. Furthermore, these researches led by these psychologists (Kolb D., 1984) (Chartier D., 2003) explain that school failure is mainly due to the lack of consideration of learning's styles which differs from one individual to another. Daniel Chartier (Chartier D., 2003) has also noticed that different learners have different ways of learning (learning style). Their success or their failure is thus related not only to the efficiency level, but also, to the ways they perceive, store and restore the information, how they build their knowledge bases. Individual human don't have the same competencies for acquiring knowledge.

Hence, the pedagogy sides of learning process must be introduced in learning systems to improve learners' results. This may be done by supplying learning systems with some reasoning capabilities to enable them to use the learner's learning style to adapt the learning process. Therefore, the description metadata model of learning object must be supplied with items that let Authors (Expert) to introduce pedagogical items within courses' descriptors, such as learning styles, pre-requisites courses and so on. These items can then be used by learning systems to generate adapted courses based on captured learners' profiles.

Being the most used learning system, we consider that SCORM LOM (IEEE, 2001) is the most appropriate learning object metadata descriptor to be extended to describe pedagogical items and particularly learning styles. This standard emerged among many others to allow reusability of educational objects and interoperability between developed learning systems. It happens that, these characteristics (re-usability and interoperability) are not enough to support learners' pedagogical profile such as learning styles. This limitation has been discussed in many research papers since the apparition of SCORM in 2000 with SCORM V1.0, modified in 2001 to SCORM V1.2 (ADL, 2001), then in 2004 to SCORM 2004 3rd edition V1.0 (ADL, 2006) and finally in 2009 to SCORM 2004 4th edition V1.1 (ADL, 2009). Referring to (ADL, 2009), SCORM LOM can be extended whenever the core set of metadata elements defined by LOM is not adequate enough to describe SCORM Content Model Components. SCORM allows two types of

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extensions' mechanism within the LOM which are:

- XML element extensions: it is permitted to add additional elements to metadata instances;
- Vocabulary extensions: list of vocabulary value proposed by the IEEE of the LOM.

Mason R.T. and Ellis T.J. (Mason R.T. and Ellis T.J., 2009) expose an approach to extend SCORM LOM with additional metadata to support adaptive learning. Baldoni M. & al. (Baldoni M. & al., 2004) propose to use ontology to add knowledge level to SCORM LOM. Milosevic D. and Brkovic M. propose as well to use ontology to expend SCOs Metadata in terms of pre-requisites (Milosevic D. and Brkovic M. ,2007).

Therefore, our objectif is to take benefit of this feature to design an adaptive learning system based on learning style. That means that a course can be planned differently according to learners' learning style. This planification will be use the different versions of the same course that have been prepared by experts for each leaning style.

This paper presents the concept of learning styles as proposed by psychologists and how it can help learners to get better results. This work reviews and presents a solution to enable SCORM LOM suporting both conceptes learning styles and pre-requisites. An architecture of such learning systems is then presented which adapts learning materials to learners based on learners' profile.

This paper is structured as follows. We present first the concept of learning style in section two and the one of learning object in section three. In section four we focus on SCORM on which we base our proposal presented in section five. Before concluding we present in section six the architecture of our system.

2 LEARNING STYLE

Many studies focus on the study of behavior of a human faced to a training session. In his book, the psychologist David A.Kolb (Kolb D., 1984) states that any person, who is in a learning situation to get a new concept, must go through a learning cycle consisting of four ordered phases. From a *concrete experience* phase of the target world, the person will be engaged in *reflective observation* phase on that experience, which will lead to an abstract conceptualization generating new hypotheses to be tested in a phase of *active experimentation*, feeding a new concrete experience that loops the cycle as shown in figure 1.

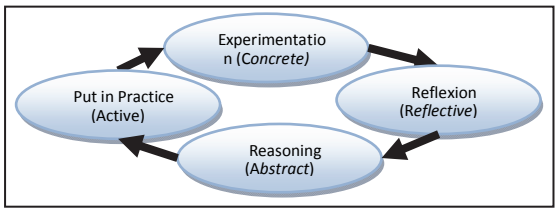

Figure 1: Kolb's Cycle.

Kolb (Kolb D., 1984) also noticed that each learner is characterized by the preferences he/she gives to one of these four phases of the learning cycle. On the basis of this learning cycle, Kolb positions the learner on two orthogonal axes: Concrete/Abstract and Active/Reflective (see Figure 1). From these two dimensions, Kolb propose four types of learning styles:

- The *Divergent* (Concrete/Reflective), is characterized by his capacity of imagination and his "emotional intelligence";
- The *Convergent* (Abstract/ Active), who likes to apply the ideas;
- The *Accommodator* (Concrete/Active), who prefers facts to theory and action to meditation;
- The *Assimilator* (Abstract/Reflective), who is interested in the concepts and theories.

Based on this theory, Professor Jean There (There J., 1998) established a standard of these learning styles called ISALEM-97 (L'Inventaire des Styles d'Apprentissage du Laboratoire d'Enseignement Multimédia).

The integration of learning styles in the training process seems to be very beneficial for learners, but some questions need to anwsered before apply it. First, how can learners be classified in their appropriate learning style? Secondly, how can we manage to present the same content, with the same objective, to different learners of different learning styles?

A first solution to these questions is to proceed as Kolb's experience propose: teach then first and then classify then after each assessment. In this case, the preparation of the content of the assessment must also take into account the classification in order to interpret the results of learners. Based on the results, a categorization of learners is performed which allows the teacher to prepare different approaches of presentation of the same content (same objective) to the various obtained classes. This approach is an ongoing and a long term work which will also situate the learner and eventually upgrade the learner to develop all his faculties of knowledge acquisition.

A second solution consists in passing a test to learners so that they can be classified as proposed by

ISALEM (Isalem-97). This test will allow the teacher to categorize these learners and then to prepare the presentations required for the subject to be taught. The major drawback of this approach is that the learner profile is fixed in advance, which does not give a chance for the learner to develop his abilities to acquire knowledge.

In his book, David Kolb (Kolb D., 1984) noted that the teacher has also preferences of learning style which influence him on preparing a learning content. Preaparing the same content in differente versions according to differente styles is thus a difficult task. It requires differente teacher with differente learning style preferences.

3 LEARNING OBJECT

The learning object is a current tendency that plays a very important role in the development of learning systems. Its goal is to produce usable and reusable digital courses in varieties of learning context situation (K.Verbert, 2004). Production of a course by an Author becomes just an assembling of existing learning objects and/or eventually a production of other learning objects that can be themselves reusable. To generalize this methodology of course design based on learning objects shared on the Web, standardization happens to be necessary. Many studies have been conducted in this context to describe precisely the features and services to ensure sharing and reuse of these objects (Forte E., & all, 1997) (Downes S., 2000) (Koper R., 2002).

Two proposals of standards for describing learning objects have emerged in recent years. The central objective concerns the indexing of learning objects for their reuse on different learning systems. The most important models and more standardized ones are:

- LOM (Learning Object Metadata), describes the object from an economic point of view (profitability, rationality and reuse) (LOM);
- SCORM (Sharable Content Object Reference Metadata), deals with object from a technical point of view (operating, control) (SCORM);
- IMS-LD (IMS Learning Design), deals with object from a pedagogical point of view (design, teaching tools, scenarios) (IMS);

Among these models, the most popular and largely used one is SCORM leading to a large variety of learning objects. This is what justifies our choice of SCORM as the underlying model of the solution that we propose. In the next part of this paper, SCORM is described and analyzed to see how it can be used to adapt learning resources to learner based mainly on his learning style and his acquired knowledge.

4 PRESENTATION OF SCORM

As described in ADL's work (ADL, 2009), SCORM allows the exploitation of learning objects on the Internet. Its main objective is to propose a formalism and a mechanism to describe and publish learning objects and control their uses.

SCORM proposes a learning object definition and exploitation process, composed of *Content aggregation, Metadata annotation and Content packing*.

4.1 Content Aggregation

The Content aggregation is based on the content Model (ADL, 2009) which describes the SCORM components used to build a learning experience from reusable learning resources. At the same time, the Content Model defines how these reusable learning resources are aggregated to compose units of instruction. A Content Model in SCORM consists in Assets, Sharable Content Object (SCO) and Content Aggregations.

4.1.1 Assets

An Asset (ADL, 2009) is an electronic representation of media, text, images, sounds, web pages, assessment objects, or other pieces of data that can be delivered to a web client. To be reused and reached within online repositories, Assets can be described with Asset Metadata.

4.1.2 Sharable Content Object (SCO)

A SCO in SCORM (ADL, 2009) is a collection of one or more Assets that include a specific launchable asset that uses the SCORM Run-Time Environment to communicate with Learning Management Systems (LMS). SCO represents the lowest level of granularity of learning resources that can be tracked by an LMS using the SCROM Run-Time Environment. SCO can be described with SCO Metadata.

4.1.3 Content Aggregations

A Content Aggregation (ADL, 2009) is an organized structure of content, which can be used to organize

learning resources on a coherent unit of learning and to schedule learning resources, which are going to be presented to learners. Once defined, a Content Aggregation can be used and reused by LMSs, that's why they are described by metadata.

4.2 Metadata Annotation

Metadata in SCORM (ADL, 2009), based on the IEEE LTSC Learning Object Metadata (IEEE, 2001); describe different levels of the Content Model of learning units, such as Assets, SCO and Content Aggregation. This description ensures the research for these resources within and across systems to further facilitate sharing and reuse. As described in IMS Learning Resource Meta-data XML Binding Specification (IMS-LR), SCORM Metadata is composed by nine (9) categories of elements: general, lifecycle, Meta-metadata, Technical, Education, Rights, Relation and Annotation, where each category regroupeds elements referring to it.

4.3 Content Packing

A content packing in SCORM (ADL, 2009) defines the structure and the behaviour of a collection of learning resources. Its purpose is to provide a standardized way to exchange digital resources between different learning systems or tools. The structure of a content packing is as shown in figure2.

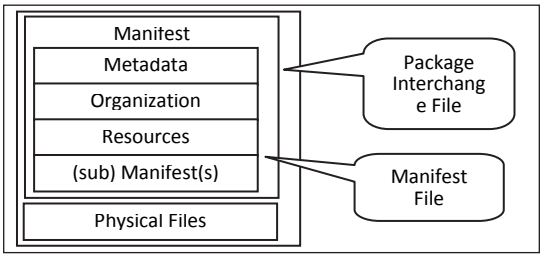

Figure 2: Typical SCORM Content Packing.

5 ADAPTING CONTENTS IN SCORM

After this overview and analysis, we present our proposal to enable SCORM to support contents based first, on learners' knowledge and second, on learner's learning style preferences.

5.1 Supporting Learner's Knowledge

In order to support learner's knowledge, learning system must maintain a knowledge profile for each learner, in which all acquired resources are hold. This information can be extracted from the "General" category of SCORM Metadata (ADL, 2009) which are: *General.Identifier, General.Title, General.Description and General.Keyword.*

Once maintained update, the learning system can use this knowledge profile to evaluate the learner's capabilities in terms of acquired Knowledge and pre-requisite knowledge.

5.1.1 Knowledge Already Acquired

Once a resource present in the schedule is acquired the adaptation process suppresses it from that schedule. This can be seen in the following scenario. Let us take for example two lessons with the organization as defined in figures 3 and 4 where S1, S2, S3, S4, S5, S6 are SCOs and A1, A2, A3, A4, A5 are Assets.

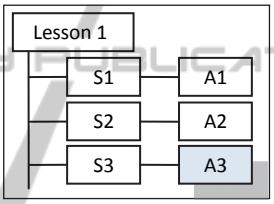

Figure 3: Learning Resource1.

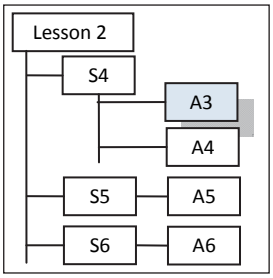

Figure 4: Learning Resource2.

Let's note that Asset A3 is both used by SCO S3 and SCO S4.

Let L1 and L2 be two learners. L1 wants to learn Lesson1 and then Lesson2, whereas L2 wants to learn only Lesson2.

As they are new in the learning system, their knowledge profile are empty.

Once learner L1 starts the learning process, the adapter schedules the Lesson1 learning resources as shown in figure 3. At the end of this learning process, the L1's knowledge profile becomes {A1, A2, A3}. As the resoure A3 is now acquired, the adapter schedules the Lesson2 learning resources as

shown in figure 5, deleting resource A3 from Lesson2.

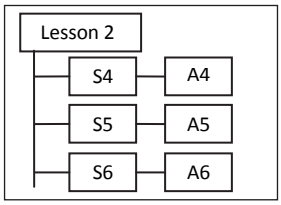

Figure 5: Organization of Learning Resource 2 adapted to learner L1.

At the end of the learning process of the Lesson2, L1's knowledge profile is {A1, A2, A3, A4, A5, A6}.

In the case of L2, the adapter schedules for the same lesson (Lesson2) the learning resources as shown in figure 4. At the end of Lesson2 learning process L2's knowledge profile is {A3, A4, A5, A6}.

This scenario confirms that it is possible to build a learner knowledge profile from the "General" category of SCORM.

5.1.2 Pre-requisite Knowledge

In the adaptation of learning resources to learner, the other most important pedagogical situation is to take into account, the pre-requisite resources when scheduling lessons. Let us illustrate this situation by the following example. Suppose that the knowledge within the learning resource S1 of Lesson1 is necessary to understand Lesson2, i.e. S1 is pre-requisite to Lesson2. Let us see now how the adapter process should schedule Lesson2 for learner L2. Referring to learner's knowledge profile and the pre-requisite resources of a specific lesson, the adapter can verify if learner is capable to learn this lesson or not. At this moment, the adapter will schedule Lesson2 to learner L2 as shown in figure 6.

At the end of the learning process L2's knowledge profile becomes {A1, A3, A4, A5, A6}.

To enable the scheduling of this type of situation, the authors must be given the possibility to specify pre-requisites resources during the description of the learning resources. Therefore, metadata must be supplied by some elements to enable the expression of such relationship. SCORM provide the "Relation" category in which the relationship between learning resources are described. Refering to (ADL, 2009), the element Relation.Kind defines all the kind of existing relationship between two learning resources. This element is bounded by a set of vocabulary defined by IEEE LOM (Dublin Core). This vocabulary is : IsParOf, HasPart, IsVersionOf, HasVersion, IsFormatOf, HasFormat, References, IsReferenceBy, IsBasedOn, Requires and IsRequiredBy.

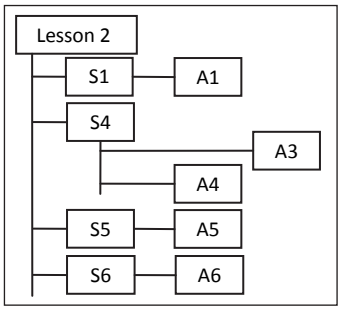

Figure 6: Organization of Learning Resource 2 adapted to learner L2.

Regarding to this description and this set of vocabulary, SCORM's Metadata doesn't support pre-requisite relationship. We thus propose to upgrade the existing set of vocabulary by the following new ones:

- *HasPrerequisite*: defines the pre-requisite resource specified on the element Relation.Resource, which is needed for the actual resource.
- *IsPrerequisiteBy*: defines the resource where the actual resource is pre-requisite.

This proposed solution enables SCORM to support the pre-requisite relationship between learning resources, by upgrading the IEEE LOM (Dublin Core) vocabulary used in Relation.Kind by HasPrerequisite and IsPrerequisiteBy. The learner's knowledge profile, can be of a great contribution in building an adapted scheduling of learning resources.

5.2 Supporting Learning Style

The second side of our contribution consists of the addition to SCORM of the very elements to let the adapter schedules learning resources based on leaning style. As it is defined, SCORM doesn't give much importance to pedagogy. Nevertheless, the "Educational" category holds some elements, which need to be further analyzed.

As mentioned earlier, David Kolb (Kolb D., 1984) proposed four types of learner : *Divergent, Convergent, Accommodator and* Assimilator.

Authors have thus to prepare four versions of the same lesson for each type of learner. See Figures 7, 8, 9 and 10 that show four versions of the same lesson but for different type of learner.

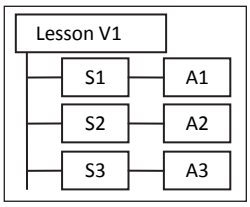

Figure 7: Lesson V1.

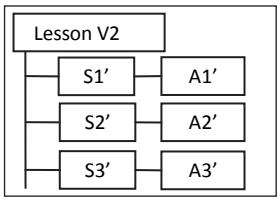

Figure 8: Lesson V2.

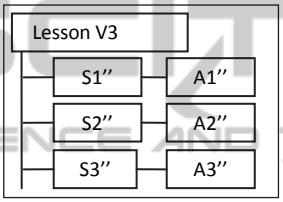

Figure 9: Lesson V3.

As we can see, the main difference between these lessons is the content of the learning resources which leads to the same learning objectives. Therefore, these four learning resources are different but are equivalent.

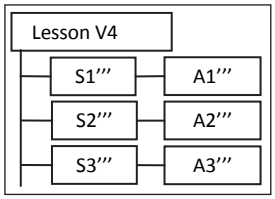

Figure 10: Lesson V4.

When applied to this example the following assumptions are valid:

1. Lesson V1, V2, V3 and V4 are equivalent;
2. Resources S1, S1', S1'', S1''' are equivalent;
3. Resources A1, A1', A1'', A1''' are equivalent;

To enable SCORM supporting learning styles it is necessary to:

1. Specify the learning style for each learning resource;
2. Specify the relationship between equivalent learning resources;
3. Keep track of the preference learning style for each learner;
4. Have a method to schedule the appropriate learning resources to learner.

5.2.1 Specifying Learning Style to Learning Resources

SCORM provides the category "Education" in which the element "Interactivity Type" indicates the flow of interactivity between learning resource and the learner. This element is bounded by a set of vocabulary defined by IEEE LOM (Dublin Core).
This vocabulary is : Active, Expositive, Mixed and Undefined (ADL, 2009).

When comparing this vocabulary to the learning styles defined earlier, it can be observed that:

1. The *Assimilator* type of learner expects information to come only from the resource. This means that an *Expositive* resource is well suited.
2. The *Accommodator* type of learner prefers to participate to the learning process by being active. He surely prefers *Active* resource.
3. The *Convergent* type of learner prefers neither pure *Expositive* resource, nor pure Active resource; but prefers applying theoretical concepts. Therefore the suitable resource is the one which is at the same time *Expositive* and *Active* resource. That is the *Mixed* resource.
4. The *Divergent* type of learner prefers neither Expositive resource, nor *Active* resource. Therefore, his preference type of resource is not proposed yet by this vocabulary.

The proposed solution which enables SCORM to support all these learning styles, is to add a new vocabulary for the remaining learning style (Reflective type).

This proposed solution, gives authors the opportunity to specify the learning style of the learning resource on its metadata.

5.2.2 Relationship between Equivalent Resources

As mentioned earlier, specifying the learning style for learning resource doesn't mean that it is a new knowledge to teach but it is another way to communicate the knowledge of an existing learning resource. Therefore, they are two different but equivalent learning resources.

The proposed solution to enable SCORM to support this kind of relationship, is to upgrade the element Relation.Kind with a new vocabulary "IsEquivalentTo".

5.2.3 Keeping Track of Learner Learning Style

To give the opportunity to the adapter to provide the right resources to learners, the learning system must keep track of learning style for each learner. A learning style profile can be associated to each learner where it is hold all his preferences learning styles. This learning style profile must be kept updated.

5.2.4 Scheduling

When applying all these proposed modification on SCORM Content Metadata, the obtained result is an adapted scheduling of learning resources based on learner profiles (knowledge profile and learning style profile). As an example, the scheduling of the four versions of the same lesson described in figures 7, 8, 9 and 10, gives the result of figure 11. Where Type1, Type2, Type3 and Type4 are the four types of learning styles as defined by Kolb.

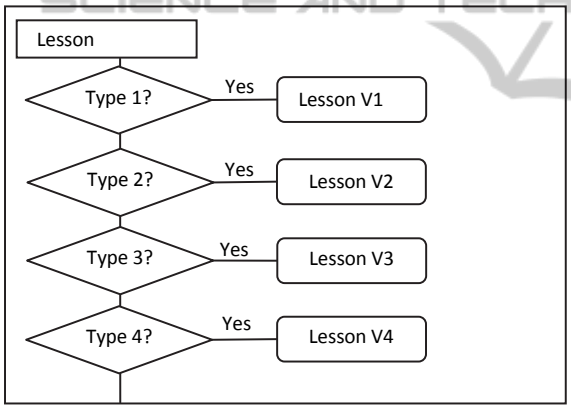

Figure 11: Organization of lesson after Scheduling.

This first scheduling gives to the learning system the ability to select the right resources depending on the learning style profile of the learner.

However, to adapt this first scheduling based on the learner profile (learning style and knowledge) and the pre-requisite resources of the selected lesson, the system must re-generate a new scheduling by adding or removing resources in the appropriate place of the learning style.

6 PROPOSED ARCHITECTURE

To support all the presented concepts of adaptation based on learner profile, the proposed architecture of the learning system is as shown in figure 12.

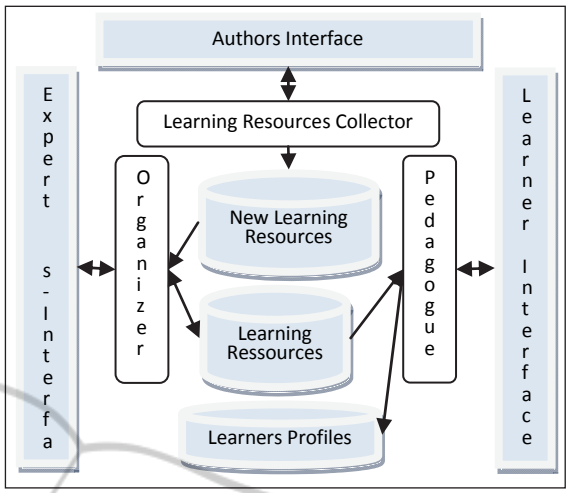

Figure 12: Architecture of a learning System.

This architecture supports the three types of users: Authors, Experts in pedagogy and learners. All these users are served by three modules and communicate with the learning system through interfaces. The roles of these modules are:

1. Learning resource collector: this module take care of all new learning resources uploaded by authors or those of other learning systems, it stock them into storage for further treatments by the Organiser;
2. Organizer: the new posted learning resources are analysed and verified if they contains pedagogical Metadata or no. If no, the human expert is solicited to add the appropriate Metadata. To be added to learning resources of the learning system, the new learning resources with pedagogical Metadata are related to the existing ones. This operation can't be done automatically but with the help of the human expert.
3. Pedagogue: this module satisfy the willing of the learner by proposing him course based on the learning resources available, the learner learning style preference and his background knowledge.

7 CONCLUSIONS

The main contribution of this paper is the introduction of the pedagogical side of the learning process into the learning systems. The pedagogical concepts introduced are the learning style and the acquired knowledge of the learner.

By this modification, learning systems become capable to adapt learning resources to the learner

based on his preferred learning style and his acquired knowledge.

This proposed solution has upgraded SCORM metadata by introducing some new vocabularies by which pedagogical concepts were introduced.

To validate this proposed solution an architecture of learning system is presented. This system is under development.

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